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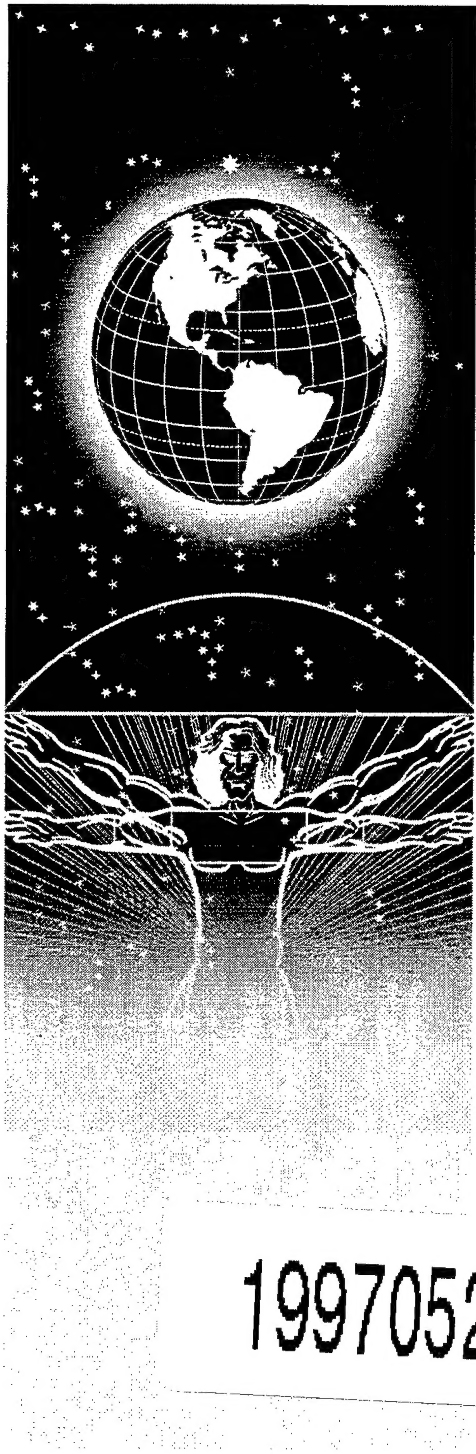

UNITED STATES AIR FORCE
ARMSTRONG LABORATORY

Preventing Work-Related Musculoskeletal Illnesses Through Ergonomics: The Air Force PREMIER Program, Volume 3B: Research Report For Level I Ergonomics Methodology Guide For Administrative Work Areas

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13. ABSTRACT *(Maximum 200 words)*
This report describes the results of a pilot test to assess the reliability, sensitivity, validity, and practicality of the Level I Ergonomics Assessment Methodology Guide for Administrative Work Areas. Overall, the pilot test provided evidence to indicate that the developed Level I Methodology assists technicians in arriving at similar solutions as would be selected by an ergonomist for administrative tasks. There was substantial agreement between technicians and the Gold Standard ergonomist for 91% of the job scenarios selected. The corrective actions selected by the technicians agreed with the solutions selected by a consensus of ergonomists 63% to 77% of the time. The job factors selected by technicians agreed with ergonomists 67% of the time.

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LIST OF ACRONYMS

AFB	Air Force Base
AFMC	Air Force Materiel Command
AFOSH	Air Force Occupational Safety and Health
AL/OEMO	Armstrong Laboratory/Occupational Medicine Division
AMDS	Aerospace Medical Squadron
ANOVA	Analysis of Variance
ANSI	American National Standard Institute
BEF	Bioenvironmental Engineering Flight
EPRA	Ergonomics Problem Area
EWG	Ergonomics Working Group
HFS	Human Factors Society
HQ AFMC/SGC	Head Quarters Air Force Materiel Command/Office of the Command Surgeon
ICC	Intraclass Correlation Coefficient
JR/PD	Job Requirements/Physical Demands (Survey)
NS	Non Significant
PEPA	Potential Ergonomics Problem Area
PHF	Public Health Flight
RULA	Rapid Upper Limb Assessment
SAS	Statistical Analysis Software
SGPM	Military Public Health
USAF	United States Air Force
VDT	Video Display Terminal
WMD	Work-Related Musculoskeletal Disorders
WPAFB	Wright-Patterson Air Force Base

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1.0 EXECUTIVE SUMMARY

1.1 INTRODUCTION TO THE LEVEL I ERGONOMICS ASSESSMENT AND PROBLEM-SOLVING METHODOLOGY RESEARCH REPORT

The U.S. Air Force has sponsored the development of standard ergonomics assessment methodology guides and management tools which will be integrated into the AFOSH Program. These methodologies and tools will be used as a means to minimize or eliminate work-related musculoskeletal disorders (WMDs) associated with routine exposure to ergonomics risk factors at Air Force installations.

This **Research Report** describes how the Level I Ergonomics Assessment and Problem-Solving Methodology for Administrative Work Areas performed in testing, and therefore, how effective it will be as a tool for providing the means for Bioenvironmental Engineering (BEF) to conduct aggressive task-based problem-solving in an Ergonomics Problem Area (EPRA). In order to obtain a clear understanding of the results, an overview of the Methodology design and development process is provided below.

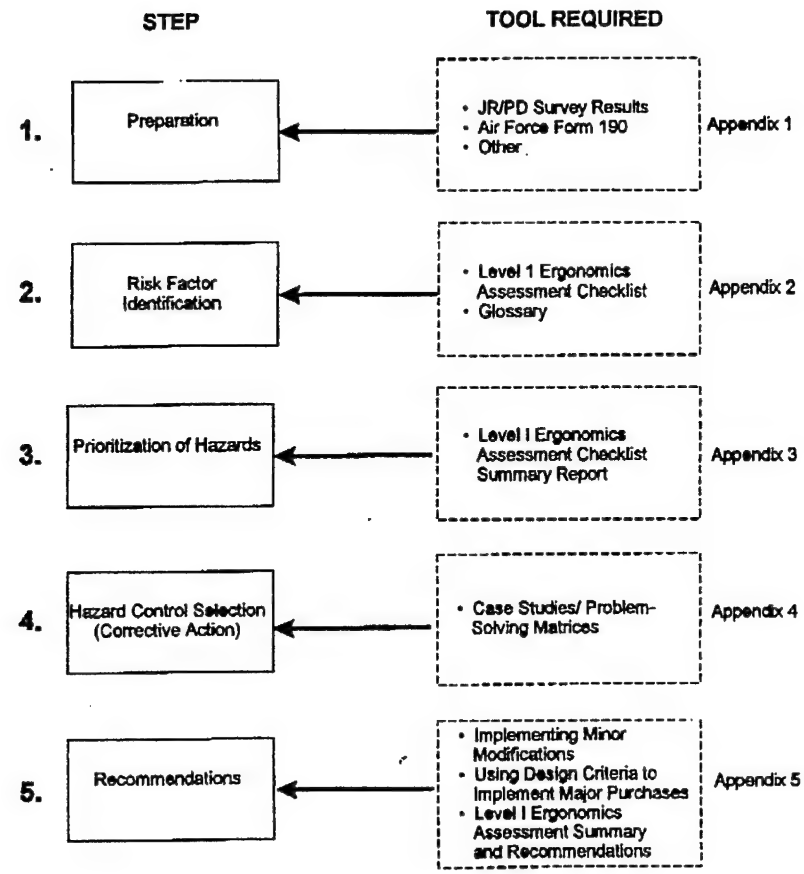
1.2 METHODOLOGY DESIGN

The Methodology, designed for use by a BEF technician with 2-3 years of experience, is applied by following five primary steps:

- Step 1. Preparation
- Step 2. Risk Factor Identification
- Step 3. Prioritization of Hazards
- Step 4. Hazard Control
- Step 5. Recommendations

The **Level I Ergonomics Assessment** process is shown in Figure 1.1.

Figure 1.1
Level 1 Assessment Process



1.3 DEVELOPMENT AND TESTING PROCESS

The above design is the result of an iterative development and testing process that benefited from the support and cooperation of Air Force personnel at several Air Force Materiel Command (AFMC) locations:

- Armstrong Laboratory/Brooks AFB, Texas
- Wright-Patterson AFB, Ohio
- Eglin AFB, Florida
- Tinker AFB, Oklahoma
- Kelly AFB, Texas

The Methodology design incorporates the results of a focused literature review, strategic site visits, criteria established by the Air Force, and input for Air Force technical advisors.

The testing and validation processes were conducted in two primary phases: alpha testing and beta testing. During the alpha phase, ergonomists tested the Methodology. During the beta phase, Air Force personnel tested the Methodology. For each phase, the

Methodology was tested for usability, reliability, sensitivity, and validity. Usability testing was performed to ensure that users would be able to apply the Methodology as intended. Reliability testing was performed to determine how consistently that application of the Methodology yielded the same results. Sensitivity testing was performed to determine if the Level I Assessment can determine the difference between actual risk levels in a job. Finally, validity testing was conducted to measure how closely the results from experienced ergonomists matched the results obtained by Air Force personnel. The methods, rationale, and results of the testing and validation are detailed in this report.

1.4 PROJECT RESULTS

The results of the validation process provide evidence of the validity, reliability, sensitivity, and practicality of the Methodology. The results are summarized below:

Validity

- All of the job factor questions were supported by scientific research. The list of job factor questions was inclusive of the Job Factors which would occur in administrative tasks.

- The overall theoretical framework of the checklist was a logical structure used in assessment tools which have been validated.

- Testing revealed that there was substantial agreement between end users and the Gold Standard Ergonomists for 91% of the Job Scenarios. This means that the assessment enabled end users to identify the *appropriate* case studies as the basis for effective control identification.

- The corrective actions selected by the end-user agreed with the solutions selected by a consensus of ergonomists 63% to 77% of the time. This result suggested that the Level I Ergonomics Assessment assists end-users in generating solutions that experts would recommend.

- There was a significant relationship between the assessment results of end-users and the Gold Standard Ergonomists.

Reliability

- The Job Factors selected by end users agreed with ergonomists 67% percent of the time.

Sensitivity

- The Methodology was sensitive enough to significantly distinguish between different levels of exposure and ergonomic risk factors (e.g., high and medium risk).

Practicality and Usability

- The Methodology received favorable usability comments and was well accepted by BEF technicians;

- The Methodology met and improved on the "time for completion" requirements established by the Air Force;

- The Methodology allowed end users to elicit solutions with a high level of reliability; and

- The Methodology is effective on a variety of Air Force administrative tasks.

The Level I Methodology for Administrative Work Areas can be considered an effective means for identifying and controlling ergonomics hazards in administrative work areas. In addition, it represents a strong foundation for developing similar approaches to reducing or eliminating the potential for WMDs in Maintenance/Inspection, Warehouse, and Assembly Work Areas.

Overall, the Methodology will enable Air Force personnel to identify appropriate solutions to the ergonomics hazards identified in administrative jobs. The specific objectives which served as the basis for the Methodology development and the actual performance of the Methodology are compared in Table 1.1.

Table 1.1
Summary of Objectives and Performance

Design Feature	Air Force Criteria/Objective	Actual Methodology Performance
Meets needs of end user	Design the Methodology for use by a BEF technician with 2-3 years of experience.	**Objective met.** • Usability comments obtained during and after beta testing indicate that the Methodology design is appropriate to the expertise of the intended user. • The use of technical "jargon" is avoided. • Clear definitions are provided to eliminate the need for risk factor interpretation. • Step-by-step instructions are provided to the Methodology user through the entire analysis and pattern-matching process. • A sample of comments: – *a separate glossary is not necessary - risk factor questions are 'no brainers'* – *provides a quick way of identifying basic improvement strategies* – *easy enough that a shop supervisor can do it* – *will help us determine if an employee complaint is consistent with what we see from the assessment*
Ease of analysis	Design the Methodology to enable the user to complete the data collection and analysis on an administrative job in 1-2 hours - the goal: minimize time requirements.	**Objective exceeded.** • In trials, the average time required by BEF technicians to complete the data collection and analysis process using the Level I Ergonomics Assessment Checklist and Checklist Scoring Summary was approximately 20 minutes.
Ease of control identification	Design the Methodology to enable the user to identify controls and develop a summary report in 1-2 hours - the goal: minimize time requirements.	**Objective exceeded.** • The control identification (pattern-matching) process required an average of approximately 17 minutes. • Since the amount of problem-solving required during the beta test was intentionally restricted (to allow statistical comparisons), it is expected that the actual control identification/summary report process will require an average of approximately 25 minutes.

Table 1.1
Summary of Objectives and Performance (Cont'd)

Design Feature	Air Force Criteria/Objective	Actual Methodology Performance
	The Methodology can be completed through visual observation and employee/supervisor interview.	**Objective met.** • Observing the job/tasks is the primary means for collecting data. • Employees are interviewed informally to obtain comments that may be useful in the hazard identification or improvement processes.
	The Methodology should enable the user to identify potentially hazardous tasks within a shop and job.	**Objective met.** • The Level I Ergonomics Assessment Checklist and Checklist Scoring Summary provides an Overall Job Priority score as well as Task Priority Score(s). – The Overall Job Priority Score enables the shop to determine which jobs (e.g., general administrative, contract specialist, etc.) to fix first. – The Task Score(s) enables a corrective action team to focus on the specific part of the job (e.g., task/writing/reviewing document, typing/keying, etc.) which contributes most significantly to ergonomics hazard exposure.
	Enable the user to determine if the content of the job and task(s) meet established ergonomics (risk factor exposure) criteria.	**Objective met.** • Risk factor exposure time is calculated automatically (the user simply circles the appropriate response): both the total task duration as well as the proportion of the task time in which the Job Factor occurs are considered. • The scoring process provides a "high", "medium", or "low" priority score for both the Overall Job and the individual tasks within the job.
	Enable the user to choose from a menu of control options (both short-term and long-term) which when implemented, will minimize the risk of musculoskeletal disorders and the hazards identified within the job and tasks.	**Objective exceeded.** • The Methodology Guide (Appendix 4) includes comprehensive Case Study Problem-Solving Matrices which provide a list of controls for 11 of the most common types of administrative tasks. • The controls are identified as *modifications/adjustments* (e.g., short-term) and *major changes* (long-term) • Each control is evaluated for its expected impact on health/safety, quality, and productivity. • Approximately 75% of the controls are in the "short-term" category and can be implemented for "no cost."

Table 1.1
Summary of Objectives and Performance (Cont'd)

Design Feature	Air Force Criteria/Objective	Actual Methodology Performance
	Provide Case Studies that will serve as the basis for the pattern-matching process used to *match* the hazards identified in the tasks with controls that will reduce employee exposure to those hazards.	**Objective exceeded.** • A section of the Methodology Guide is devoted to design criteria for implementing the controls that are most appropriate for the job. • One section describes the process used to implement modifications and adjustments to current workstations (e.g., how to raise the monitor, how to make the proper chair adjustments for a "less than ergonomic" chair, etc.). • Another section provides product evaluation criteria that may be used when prior to selection and purchase of new equipment or accessories (e.g., chairs, document holders, etc.)
	Determine which type(s) of additional (Level II) analyses may be used if additional data is required.	**Objective met.** • The title page for each Case Study provides direction on the type of Level II analysis that may be completed to provide greater detail on ergonomics risk factor exposure.
	The Methodology identifies metrics which will be used to judge the impact of ergonomics improvements on employee health, safety, and performance (e.g., quality, productivity).	**Objective met.** • The title page for each Case Study provides recommendations for the type of performance measures that may be used to justify solutions and/or measure the impact of those improvements. • The design of the Level I Ergonomics Assessment Checklist provides the means for re-evaluating the job after changes have been made. "Before" and "After" Job, Task, and Body Region Priority ratings can be compared to - determine the immediate benefits to employee health and safety. • Additional information on metrics will be provided during the Follow-Up and Performance Measurement phase of the Project.

Table 1.1
Summary of Objectives and Performance (Cont'd)

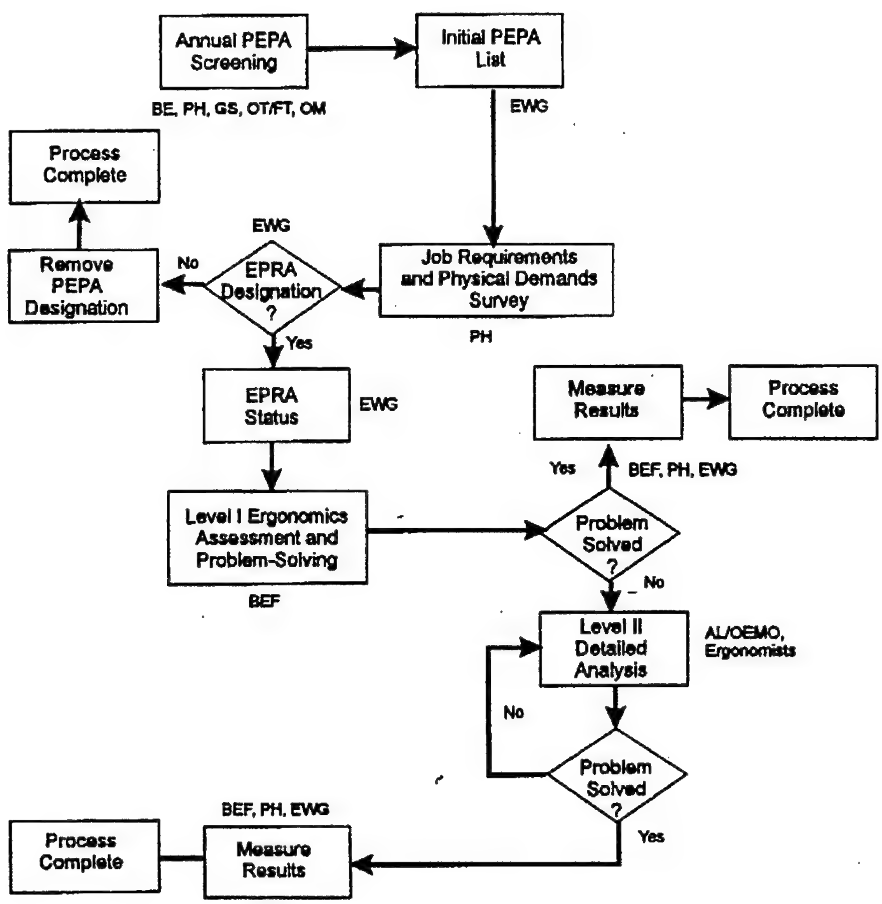
Design Feature	Air Force Criteria/Objective	Actual Methodology Performance
	The Methodology will incorporate lessons learned from the Job Requirements and Physical Demands (JR/PD Survey) developed for use by Public Health (PHF).	**Objective met.** • The User's Methodology describes how to make the best use of information obtained from the Survey. • Information obtained from Part III of the JR/PD Survey provides an initial basis for Job Selection. • The 11 Case Study Problem-Solving Matrices were developed to correspond the administrative task types listed in Part III of the survey. • The identical body region categories are used in the survey and in the Level I Ergonomics Assessment Checklist. • The format and style of the documents are consistent.

2.0 DEVELOPMENT PROCESS SUMMARY

2.1 USE OF THE METHODOLOGY IN THE TIERED APPROACH TO PROBLEM-SOLVING

The primary goal of an installation ergonomics program is to prevent work-related musculoskeletal disorders (WMD) among employees routinely exposed to ergonomics risk factors. The basic elements of an installation ergonomics program include: Potential Ergonomics Problem Area (PEPA) designation, Ergonomics Problem Area (EPRA) designation and removal, work area analysis, medical management, and training and education. Both qualitative (PEPA) and quantitative (EPRA) screening techniques are used in sequential fashion to identify employees at risk. The flowchart in Figure 2.1 describes the ergonomics program process.

Figure 2.1
Ergonomics Problem-Solving Process



The Level I Ergonomics Assessment and Problem-Solving Methodology Guide for Administrative Work Areas, which was developed based on the results discussed in this Research Report, provides BEF with a process for conducting a basic ergonomics assessment and, through use of a simple pattern-matching process, identifying realistic controls that will effectively minimize or eliminate employee exposure to ergonomics hazards in jobs in EPRA designated administrative areas.

2.2 GENERAL RATIONALE FOR THE METHODOLOGY

The requirements for the Methodology design were specified by from the Headquarters Air Force Materiel Command, Office of the Command Surgeon (HQ AFMC/SGC) and Armstrong Laboratory. Both organizations desired an **effective** and **efficient** analysis and problem-solving process that could be applied to the full variety of Air Force administrative work areas. The Methodology was to be designed to reflect the technical capabilities of a Bioenvironmental Engineering (BEF) technician with only 2-3 years of experience. In addition, the process was to place **primary** focus on identifying appropriate controls. Due to the high demands already placed on BEF personnel (e.g., responsibilities for non-ergonomics-related activities) and the potential lack of ergonomics expertise, the Air Force requested that a "pattern-matching" process be created which would:

- minimize the time requirements for assessment and control identification; and
- enable the Air Force to benefit from the expertise of ergonomists who have had years of experience in addressing ergonomic hazards in administrative areas.

2.2.1 Objectives. The Methodology is designed to enable the user, primarily through visual observations and employee/supervisor interviews, to:

- identify potentially hazardous tasks within a shop and job;
- determine if the content of the job and task(s) meet established ergonomics (risk factor exposure) criteria;
- determine which type(s) of additional (Level II) analyses may be used if further quantification of ergonomics hazards is required; and
- choose from a menu of control options (both short- and long-term) which when implemented, will minimize the risk of musculoskeletal disorders and the hazards identified within the job and tasks.

The Methodology is designed to enable the user to complete data collection and analysis on an administrative job in 1-2 hours, and complete the control identification and summary report in 1-2 hours. The Methodology includes case studies for typical administrative tasks. The case studies serve as the basis for the pattern-matching process that will be used to "match" the hazards identified in the tasks with controls that will reduce employee exposure to those hazards. The Methodology identifies metrics which will be used to evaluate the impact of ergonomics improvements on employee health, safety, and performance (e.g., quality, productivity).

2.2.2 Description. Each of the objectives was accomplished by developing a Level I Ergonomics Assessment Checklist, which is an observation-based "checklist," and Case Study Problem-Solving Matrices which provide a rich "controls database" for addressing ergonomics hazards. The Level I Ergonomics Assessment Checklist requires no measurement. The technician collects risk factor exposure data by observing the task and talking with the employee. The checklist results can be directly "matched" to the "database" of ergonomics hazards and recommended controls provided in one (or more) of 11 Case Study Problem-Solving Matrices. The Matrices are designed to represent the most common Air Force Administrative tasks. *A detailed description of the pattern-matching process is described in detail in The Level I Ergonomics Assessment and Problem-Solving Methodology Guide for Administrative Work Areas.*

2.3 SCIENTIFIC BASIS FOR THE METHODOLOGY DESIGN

2.3.1 Literature Review

2.3.1.1 Method. A literature review was conducted to identify existing methodologies that could be used as the basis for the Level I Methodology for Administrative Work Areas. Initial results of the review indicated that at the present time, comprehensive ergonomics analysis/problem-solving methodologies which use pattern-matching as the basis for control identification do not exist.

As a result, the literature review was targeted to identify *analysis methods* upon which one part of the Methodology, the Level I Ergonomics Assessment Checklist, could be based. Sources for these methods included: peer-reviewed research articles, voluntary (or proposed voluntary) standards, and proprietary and confidential sources. Thirty-two analysis methods were identified and evaluated. Of the 32 methods identified, three were drawn from standards, eight were drawn from journals, and the remaining 21 come from proprietary and confidential sources.

An evaluation questionnaire was developed. The questionnaire is divided into three sections: Subjective Questions, Objective Questions, and Validation Questions.

2.3.1.2 Evaluation Results. Table 2.1 summarizes the evaluation results. Included in the table are the methods which achieved the highest ratings for each of the objective, subjective, and validation questions. The feature(s) of the method which were most responsible for the high rating is also discussed. These features were considered as a foundation from which an effective Level I Ergonomics Assessment Checklist could be constructed. In some instances, the evaluators have provided comments on desirable features even though none of the methods achieved a high rating.

Table 2.1
Literature Review Results

Factor	Methods Which Achieved the Highest Ratings	Desirable Feature(s)
1. Face Validity Checklist seems to measure what it is supposed to measure	• OSHA Draft Checklist, 1995 (U.S. Dept. of Labor, 1995) • ANSI Z365 Checklist, 1995 (Samples #1 and #2) (ANSI, 1992)	• List of risk factors compared to a time exposure scale • All major risk factors considered
2. Overall Understandability When you first look at the tool, you can immediately tell what's going on	• OSHA Draft Checklist, 1995 [1] • ANSI Z365 Checklist [2] (Samples #1 and #2) • PLIBEL, Kemmlert (1994) • Job Evaluation Checklist, 1990 (The Joyce Institute, 1990)	• Matrix/table format • Risk factors listed in a column • Number of response choices limited to reduce variability
3. Ease of Answering Questions Questions are understandable and quick to answer	• OSHA Draft Checklist, 1995 [1]	• Illustrations provided with each question • Concise question descriptions • Exposure cut-off levels clearly defined/quantified
4. Ease of Scoring Scoring is understandable and quick	• ANSI Z-365 (Sample #2) [2]	• Easiest scoring strategies: addition of a column of numbers, count occurrences of check marks, or picking the highest number
5. Checklist Completion Speed Can be filled out quickly	• ANSI Z-365 (Sample #2) [2]	• Minimum number of pages • Minimum number of questions • Simple scoring procedures
6. Ease of Use at the Work site Can be easily completed at the work site	• ANSI Z-365 (Sample #2) [2]	• Single page format • Large size text fonts • Reasonable levels of information on a page
7. Objectivity The questions and scoring are not impacted by different interpretations	• ANSI Z-365 (Sample #1) [2] • OSHA Draft Checklist [1]	• Well-defined questions • Exposure levels clearly defined/quantified • Scoring levels quantified and operationally defined

Table 2.1
Literature Review Results (Cont'd)

Factor	Methods Which Achieved the Highest Ratings	Desirable Feature(s)
8. Minimal Training/Technical Knowledge Required	• OSHA Draft Checklist [1] • ANSI Z-365 (Sample #2) [2]	• No technical jargon (uses "reaching" instead of "shoulder abducted")
9. Relevance of Questions to Typical Work Situations Questions reflect realities in the work environment	• OSHA Draft Checklist [1] • Office/Computer Checklist [4]	• Illustrations of "real" work situations • Questions worded to provide examples of "real world" occurrences of risk factors
10. Flexibility Checklist usable for a variety of different types of tasks	• Uniroyal Industrial Ergonomics Checklist (The Joyce Institute, 1995) • OSHA Draft Checklist [1]	• Questions address risk factors which can occur in a wide variety of tasks • Address visual, environmental issues
11. What are the outputs of the analysis?	• Job Evaluation Checklist [4] • OSHA Draft Checklist [1]	• Ratings provided for multiple body regions and the overall job • Provides direction for problem solving
12. Equipment Required	• ANSI Z-365 (Sample #2) [2] • Uniroyal Industrial Ergonomics Checklist [5]	• No equipment (e.g., calculator or computer) should be required
13. Total Number of Pages (including supporting materials)	• ANSI Z-365 (Samples #1 & 2) [2] • Uniroyal Industrial Ergonomics Checklist [5] • Design checklist, Lifshitz & Armstrong, 1986	• Minimal number of pages desirable
14. Is there any research to support the tool?	• PLIBEL [3] • RULA, McAtamney & Corlett, 1993 • Upper Extremity Checklist, Keyserling et. al., 1993 • Design checklist [6] • Ergonomics job analysis method, Stetson et. al., 1991	• Tool supported by research
15. Test/Retest Reliability Same analyst completes more than once/reliability demonstrated	• Ergonomics job analysis method [9]	• Research conducted, favorable result • Clearly defined questions and rating scales • Minimum interpretation required • Resistant to minor changes in worker technique

Table 2.1
Literature Review Results (Cont'd)

Factor	Methods Which Achieved the Highest Ratings	Desirable Feature(s)
<u>16. Inter-Analyst Reliability</u> Multiple analysts complete the checklist/reliability demonstrated	• RULA [7] • PLIBEL [3] • Ergonomics job analysis method [9]	• Research conducted, favorable result • Clearly defined questions and rating scales • Minimum interpretation required • Resistant to minor changes in worker technique
<u>17. Method Sensitivity</u> Discriminates between low and high risk jobs	• RULA [7]	• Research conducted, favorable result • Time exposure scale allows varying levels of exposure • Minimum number of questions
<u>18. Content Validity</u> Uses measures supported in literature	• PLIBEL [3]	• Research conducted, favorable result • Questions/Job Factors are supported in the literature.
<u>19. Concurrent Validity</u> Provides information close in value to that from a more detailed analysis	• PLIBEL [3] • Upper Extremity Checklist [8]	• Research conducted, favorable result • Collects similar information to that obtained by more detailed analysis but collects the information in a more concise manner
<u>20. Predictive Validity</u> Results predicts or correlates with injuries, complaints, symptoms	• Design checklist [6] • RULA [3]	• Research conducted, favorable result • Job factor questions supported by research which indicates a relationship between the job factor and discomfort or injuries.
<u>21. Practicality: Ease of Use</u> Measures of overall ease of use and applicability	• Upper Extremity Checklist [8]	• Research conducted, favorable result • Matrix/table format • Illustrations for each question • Well-defined questions • Simple scoring procedures
<u>22. Practicality: Speed of Completion</u> Minimal time required to complete checklist	• Ergonomics job analysis method [9]	• Research conducted, favorable result • Minimum number of questions • Minimum number of pages • Completion time meets or is under specified completion time objectives

2.3.1.3 Design Objectives for the Level I Ergonomics Assessment. As a result of the literature review, several additional design objectives were identified as the basis for developing the Level I Ergonomics Assessment. These objectives, as well as those specified by the Air Force, are listed in Table 2.2.

The remainder of this Research Report provides specific information on the practical and scientific basis for the Guide Design.

Table 2.2
Development Objectives for the Level I Ergonomics Assessment

Air Force Objectives
• Task-based, problem-solving checklist
• Complete by BEF technician without assistance from engineer
• Include visual, musculoskeletal, environmental issues (organizational issues excluded by request of Air Force)
• Checklist completion based on real-time observation as well as employee interview
• Level of musculoskeletal stress rated by body part and overall for the job
• Provides numerical "priority" rating scale
• Analysis of results indicates which aspects of the task and/or workplace may be modified to achieve the most significant improvement
• Indicates the type of detailed analysis (Level II) which is most appropriate when quantification of risk factors is desired
• Enables technician to measure results/impact of workplace improvements
• Applicable to majority of administrative jobs
• Consistent with Job Requirements and Physical Demands Survey (administered by PHF)
Additional Objectives Based on Literature Review
• Considers all risk factors supported by the literature
• Avoids the need for taking physical measurements
• Provides examples and illustrations of real world occurrences of risk factors for each question
• Questions designed such that the assessment is resistant to minor changes in worker technique
• Minimizes the use of technical "jargon"
• Provides clear and concise definition for questions and rating scales; minimize the need for interpretation
• Uses a time-exposure scale for making judgments about risk factor; include exposure frequency and task duration
• Defines/quantifies exposure levels
• Minimizes calculations required for scoring
• Provides risk/priority ratings for multiple body regions and overall job
• Provides numerical results and operationally defines scores
• Requires a minimum number of pages
• Uses large text/fonts

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3.0 PRACTICAL AND SCIENTIFIC BASIS FOR LEVEL I ERGONOMICS ASSESSMENT CHECKLIST

The Level I Ergonomics Assessment Checklist is comprised of four parts:

- Part I - Work Content
- Part II - Job Factors
  - Shoulder/Neck
  - Hands/Wrists/Arms
  - Back/Torso
  - Legs/Feet
  - Head/Eyes
- Part III - Environmental Factors
- Part IV - Employee Suggestions

3.1 PART I: WORK CONTENT

The list of tasks included in the Work Content Matrix were taken from Part III of the Job Requirements and Physical Demands Survey (administered by PHF). These tasks were extracted from the Dictionary of Occupational Titles (U.S. Dept. of Labor, 1991). Initial prototype testing indicated, however, that perceived redundancies in task types caused duplication in assessment effort. As a result, modifications were made to eliminate overlap between tasks (e.g., "keying/typing" and "mousing" combined into "Use of Computer").

The original and final task lists are provided in Table 3.1.

Table 3.1
Tasks Included in Work Content Matrix

Original Task List	Corresponding Final Task List	Rationale for Change
Heavy data entry/keying only	Use of computer/general word processing • keying/typing • mousing	Remove assessment redundancy with mousing task
Customer service/heavy phone use	Calling (telephone use)	Task/title simplification - increase applicability to all administrative jobs
Accounting/keying with high visual demands/use of calculator	Use of calculator/numerical pad	Task/title simplification - increase applicability to all administrative jobs
CAD operator or users of oversized VDTs	Drafting/illustrating (CAD/graphics)	Task/title simplification - increase applicability to all administrative jobs
Desktop publishing/high mouse use (mousing)	(See "use of computer.." above)	Remove assessment redundancy with keying/typing task
Filing/general administrative tasks/copying	Copying	Filing and copying are unique tasks
Monitoring visual displays/radar scope/vigilance tasks	Monitoring (vigilance tasks)	Task/title simplification
Printing/stapling	Stapling	Printing excluded based on direction from Air Force - printing function handled by contractors
Writing/illustrating	Writing/reviewing documents	Task/title simplification - increase applicability to all administrative jobs
Officers/technicians administrative workstations	Filing/general administrative	Task simplification - filing applicable to all administrative jobs
Microscope work	Microscope work	No change
	Lifting	Additional task type to reflect potential lifting component in some administrative jobs

Critical tasks are the tasks which are considered during checklist completion. The cut-off for critical tasks was selected to be one or more hours. Here, based on direction from AL/OEMO, a departure was made from the PHF JR/PD Survey tool, which uses a cut-off of two or more hours. The reason: the Level I Ergonomics Assessment Checklist requires a greater sensitivity than the JR/PD Survey/screening tool because jobs are subdivided into tasks. In addition, the selection of a lower cut-off increases the tool's ability to detect tasks which are performed for a limited duration but for which a cumulative effect across tasks could be significant.

The decision about Critical Tasks suggests that, when establishing priorities for problem-solving, tasks which occur for less than 1 hour per day (total accumulated time performing the task) should not be considered as a primary concern. This is consistent with the hazard-control prioritizing philosophy included in the AFOSH program.

The exception to this rule is for tasks which involve lifting or manual handling. These tasks are to be considered critical tasks regardless of the frequency.

3.2 PART II: JOB FACTORS

3.2.1 Format. The checklist design and question/response format was selected to achieve maximum consistency with the JR/PD Survey while still providing a tool which is sensitive enough to quantify risk factors at the job/task level.

Part II is divided into *five* sections by body region. These body regions correspond to the body region structure employed in the survey tool and the individual risk factors associated with each body region are provided. This structure is similar to that used in the PLIBEL analysis method [3].

The checklist is designed as a table or matrix which lists Job Factors (risk factors) in the left column and frequency/exposure-based responses to the right. This table format is widely used for "Level I" analysis methods (e.g., OSHA Draft Ergonomics Checklist; ANSI Z-365 Draft Checklists [2], Upper Extremity Checklist [8], Ergonomic Job Analysis Method [9]) because it is fast and easy to complete.

To satisfy the objective for providing a task-based problem-solving Methodology, the Level I Assessment Checklist format enables the user to assess exposure to ergonomics risk factors for each of the tasks that make up the larger job. This feature is unique to the Level I Ergonomics Assessment Checklist and provides the basis for assessing the overall job exposure (for within-shop prioritization purposes) while, simultaneously providing individual task exposure information. The task exposure data will enable the technician to prioritize the focus of problem-solving efforts based on the individual task which contributes most significantly to the overall risk factor exposure.

3.2.2 Question Selection. Job Factor questions are based on specific ergonomics risk factors reported to contribute to WMDs. When appropriate, questions from the JR/PD Survey were incorporated into *this checklist* to maintain consistency. Additional Job Factor questions were drawn from or based on analysis methods reported in peer review journals, from existing voluntary standards (e.g., OSHA Draft Ergonomics Standard [1], ANSI Z-365 Draft Standard [2], ANSI-HFS 100-1988 VDT Standard [11]), or extrapolated from established risk factors (e.g., stressful postures, excessive force, etc.).

The basis for each Job Factor questions is presented in Table 3.2. The table notes if reliability and/or validity has been reported for each question and specifies if the question was substantially altered for inclusion in the Level I Ergonomics Assessment Checklist. *(Note: Minor modifications were made to all questions in order to maximize consistency in verbiage and presentation.)*

Table 3.2
Original Source and Treatment of Job Factor Questions

Question Number	Original Source	Adapted from JR/PD	Reliability & Validity Reported	Substantial Alterations from Original
1	Chaffin, D.B., Andersson, G.B.J., Occupational Biomechanics, John Wiley & Sons, New York, 1984, pp. 336-341.	Yes JR/PD #5	Yes	
2	Putz-Anderson, V., Cumulative trauma disorders: A manual for musculoskeletal diseases of the upper limb, Taylor & Francis, London, 1992, p. 52.	Yes JR/PD #5	Yes	
3	[3], pp. 336-341.			Yes
4	[13]	Yes JR/PD #4		Yes
5	Snook, S.H., Ciriello, V.M., 1991, The Design of Manual Materials Handling Tasks: Revised Tables of Maximum Acceptable Weights and Forces. *Ergonomics*, Vol. 34, No. 9.	Yes JR/PD #3	Yes	

Table 3.2
Original Source and Treatment of Job Factor Questions (Cont'd)

Question Number	Original Source	Adapted from JR/PD	Reliability & Validity Reported	Substantial Alterations from Original
	Chaffin, D.B., 1973, Localized muscle fatigue: Definition and measurement. *J. Occup. Med.*, Vol. 15, pp. 346-354. Dale, W.A., 1982, Thoracic outlet compression syndrome, *Arch. Surg.*, Vol. 117, pp. 1437-1445. Tyson, R.R., and Kaplan, G.F., 1975, Modern concepts of diagnosis and treatment of thoracic outlet syndrome. *Orthop. Clinics of North America*, Vol. 6, pp. 507-519.	Yes JR/PD #7		
7	[12], pp. 336-341.	Yes JR/PD #6	Yes	Yes
8	[12], pp. 356. [13], pp. 54.	Yes JR/PD #8	Yes	Yes
9	[12], pp. 356. [13], pp. 54.	Yes JR/PD #9	Yes	Yes
10	[12], pp. 356.	Yes JR/PD #11		Yes
11	[2], pp. 6-4.		Yes	Yes
12	[9], pp. 927-937	Yes JR/PD #21	Yes	Yes
13	[2], pp. 6-3. [12], pp. 356. [13], pp. 65-66.	Yes JR/PD #12	Yes	Yes
14	[1]	Yes JR/PD #18	Yes	Yes
15	Nachemson, A. and Elfstrom, G., 1970, Intravital dynamic pressure measurements in lumbar discs. *Scandinavian Journal of Rehabilitation Medicine*, Suppl. 1. [12], pp. 304.	Yes JR/PD #23	Yes	Yes
16	Van Wely, P., 1970, Design and disease, *Appl. Ergon.*, Vol. 1, pp. 262-269.	Yes JR/PD #25	Yes	Yes

Table 3.2
Original Source and Treatment of Job Factor Questions (Cont'd)

Question Number	Original Source	Adapted from JR/PD	Reliability & Validity Reported	Substantial Alterations from Original
17	Fard, H. Mital, A., 1993, A psychophysical study of high and very high frequency manual materials handling - Part I: Lifting and Lowering, *Int. J. Ind. Ergon.*, Vol. 12, pp. 127-141, 143-156. Kumar, S., 1995, Development of predictive equations for lifting strength, *Appl. Ergon.*, Vol 26, No. 5, pp. 327-341.	Yes JR/PD #30	Yes	Yes
18	[12], pp. 190-212. Waters, T. Putz-Anderson, V., Garg, A., (1994). Applications Manual for the Revised NIOSH Lifting Equation. U.S. Dept. of Health and Human Services, Centers for Disease Control, Cincinnati, OH.	Yes JR/PD #33		Yes
19	[19], pp. 262-269.		Yes	Yes
20	Konz, S. 1994, *Ergonomics*, Vol. 37, No. 4, p. 677. Ryan, G.A., 1989, Musculoskeletal symptoms in supermarket workers, *Ergonomics*, Vol. 32, No. 4, pp. 359-371.	Yes JR/PD #34		
21	[1]	Yes JR/PD #31	Yes	
22	Bergqvist, U., 1995, Video display terminal work - A perspective on long term changes, *Int. J. Ind. Ergon.*, Vol. 16, pp. 201-209.	Yes JR/PD #37		Yes
23	Canadian Standards Association, Office Ergonomics: A National Standard of Canada, 1989, pp. 54-56.	Yes JR/PD #35		Yes
24	[1], pp. 11. [25], pp. 56.			
25	[25], pp. 56.			
26	[11]	Yes JR/PD #38		Yes

3.2.3 Question/Response Structure and Scientific Basis. The checklist is composed of a series of questions which describe postural deviations, forces, or localized contact stresses for each region of the body. Each question asks if Job Factor exists in the task being evaluated. If the Job Factor is identified, the checklist asks for a response which estimates the time-based exposure to that risk factor. The checklist design automatically assigns a score which corresponds to the estimated exposure time for that Job Factor.

A large body of research confirms that the existence of postural deviations, forces, localized contact stress, and high repetition rates (or continuous exposure) in a job can lead to muscular fatigue and WMDs. These factors are called, "primary risk factors." A complete listing of references for each of the primary risk factors is provided in Keyserling [8, 26].

Unfortunately, however, the precise magnitude/duration of exposure to each Job Factor that causes WMDs has not been determined through research. This research report does not attempt to establish a cause-effect relationship. Still, some basic concepts are understood regarding how these risk/job may factors interact and contribute to localized discomfort, pain, etc., which are recognized as pre-cursors to WMDs. Silverstein, et. al. [28, 29] found that repetition (i.e., exposure time) and force have a multiplicative effect when they co-occur in a job. Reynolds, et. al. [30] added postural deviation to this equation, suggesting that exposure can be defined as the union of force and postural deviation multiplied by the daily frequency (i.e. amount of exposure). Equation 1, provided in Figure 3.3, expresses this concept. Notice that postures can be thought of as forces exerted internally in the body. Localized contact stress can also be thought of as a force exerted by an external object. All risk factors can be translated into a force experienced internally within some region of the body over a period of time.

Thus, an approach which compares a series of posture/force-related Job Factor questions to an exposure scale, has been suggested in the literature.

For the Level I Ergonomics Assessment Checklist, exposure time is measured by considering the total task duration and as well as proportion of the task time in which the Job Factor occurs. Both task duration and prevalence of the Job Factor within the task are critical to making a correct assessment of the total exposure to that risk factor. For example, a task may be performed all day long (e.g., once every 15 minutes) but the prevalence of the Job Factor is low (e.g., 5% of the task). Conversely, the prevalence of the Job Factor may be high (e.g., performed continuously, 40 times/minute) but the task duration may be low (e.g., 30 minutes per day). The highest exposure of a Job Factor occurs when both the task duration and the Job Factor prevalence within that task are high. It is critical to be able to discriminate between different levels of task duration and Job Factor prevalence in order to accurately assess and prioritize jobs for corrective action based on overall exposure. Notice, as well, that Job Factor prevalence

can be defined in a number of different ways (e.g., as a repetition rate or as a percentage of time) depending on if the activity is continuous or repetitive.

The more common checklists used in industry seek to address the issue of task duration and Job Factor prevalence in a number of different ways. Unfortunately, only a small number of these checklist tools have been formally validated. Furthermore, there is even less research which actually prescribes the most effective way to consider both task duration and Job Factor prevalence.

The sample checklist provided in the OSHA Draft Standard [1] uses a pre-screening approach for which the user first considers task duration then considers the duration of the risk factor within each task. Finally, the user responds to each risk factor question by indicating the total daily duration of the risk factor in all tasks. This approach has a significant drawback in that an extra step is required to estimate risk factor duration. In addition, this approach is more effective for estimating exposure from continuous postures and less effective for repetitive movements.

The ANSI Z-365 Sample Risk Factor Checklist (Sample #1) [2] takes into account both total task duration and Job Factor prevalence (expressed as "repetition rate"). Reynolds, et. al. [30] expresses exposure as daily output (or number of repetitions per day). This works well for repetitive activities but is not as effective for continuous postures.

3.2.4 Scoring

3.2.4.1 Scaling Function. Three scoring levels were selected as response choices for each Job Factor: "Frequently", "Sometimes", and "Never". The definitions of each exposure level are defined below:

for each Job Factor, score:

- **Frequently (F)**: if **BOTH**
  - **Task** is performed greater than 4 hours per day **AND**
  - **Job Factor** occurs greater than 1/2 of task time
- **Sometimes (S)**: Job Factor **occurs** but does not meet the conditions for a Frequently
- **Never/NA (N)**: if the Job Factor does not occur **OR** is not applicable.

Obtaining an estimate of the multiplicative effect between force and exposure time is accomplished through the use of a score of "4", for Frequently responses, and a score of "1", for Sometimes responses. The use of a task duration cut-off of greater than 4 hours per day is supported in several resent articles (OSHA Draft Ergonomic Protection Standard; Kuorinka et. al., 1979; [29, 26]. The use of a Job Factor prevalence cut-off of greater than 1/2 of the task time is supported by Silverstein et. al. [29].

Some Job Factor questions have different scores for Frequently and Sometimes (e.g., F=2 S=1 or F=4 S=2). This scoring strategy enables the Checklist to provide the appropriate "weight" to Job Factors which appear to have a lesser or greater impact on the development of discomfort. The weighting was based on a consensus decision among TJI/ADL Ergonomists who considered the likely impact of specific risk factor exposure to past employee (pain/discomfort) complaints. For lifting tasks, F=4, S=4 is used to indicate that risk factors associated with lifting tasks are less dependent upon exposure.

3.2.4.2 Body Region Scoring. For each task, within a single body region, the scores for all Job Factors identified are summed. This summative operation simulates the summative affect across risk factors on a single body region. For instance, consider a person who is cradling the telephone and working with the arms held away from the body unsupported. In this case, one would expect that a higher priority score would be obtained than if the person were cradling the telephone only.

Task scores represent the column total for all Job Factors in a single body region. These task scores are transferred to the Checklist Scoring Summary (Section 2, Scoring Summary).

3.3 PART III: CHECKLIST/ENVIRONMENTAL FACTORS

3.3.1 Questions. The environmental factors are designed and listed in a format similar to that used for the body regions. The basis for the questions is presented in Table 3.3.

Table 3.3
Original Source and Treatment of Environmental Factor Questions

Question Number	Original Source	Adapted from JR/PD	Reliability & Validity Reported	Substantial Alterations from Original
27	Kjellberg, A. Landstrom, U., 1994, Noise in the Office: Parts I & II, *Int. J. Ind. Ergon.*, Vol. 14, pp. 87-118.	Yes JR/PD #36		Yes
28	[11], pp. 15. [26], pp. 69.			Yes
29	ASHRAE Standard 62			Yes
30	[26]			Yes

3.3.2 **Scoring**. The Environmental Factors are scored on an agreement scale. A score of 4 is given for "Strongly Agree" responses while a score of 1 is given for "Agree" responses. A score of 0 is given for all other responses.

The environmental rating scale was established to correspond to the priority rating scale used for the body regions. This scale also has three levels: high, medium, and low. The logic for the cut-offs for high, medium, and low are based on a consensus judgment of TJI/ADL ergonomists:

- A medium priority rating corresponds to **one** *Strongly Agree* environmental factor or **four** *Agree* environmental factors.

- A high priority rating corresponds to **two** *Strongly Agree* environmental factors or **eight** *Agree* environmental factors.

Ergonomist consensus considered the likelihood that exposure (based on employee perception) to several Environmental Factors would cause the employee to report a concern, or whose job performance might be adversely impacted.

3.4 EMPLOYEE SUGGESTIONS

This section is included to reflect the benefits of employee involvement. While employees may not be qualified to **conduct** the Level I Ergonomics Assessment Checklist, they can provide helpful suggestions and invaluable assistance for prioritizing the focus of any problem-solving efforts.

3.5 FINAL SCORING AND RESULTS INTERPRETATION

A tabulation matrix (Scoring Summary section of the Ergonomics Summary Report) is used to calculate the priority ratings for each body region, task, and overall for the job.

The **Scoring Summary** design resulted from a combination of findings from the literature review as well as the consensus judgment from experienced TJI/ADL ergonomists. In the literature, there is a lack of validated methods for determining a "cut-off" between "ergonomics problem/risk of WMD" and "no ergonomic problem/no risk of WMD." Therefore, the scoring concept and results generated by the Checklist are designed to **prioritize** the need for corrective action based on the highest exposure to ergonomics risk factors. In other words, a "High" rating means **that exposure to risk factors which have been associated with WMDs** is high. It does not mean that the risk for injury is high. *The ergonomics research community continues to work towards providing a dose-response relationship*. When interpreting results, the technician is instructed to focus problem-solving efforts on any job, task, body region which is rated "high" or "medium."

The priority rating scale has three levels: high, medium, and low. The logic for the cut-offs for high, medium and low are based on:

- a medium priority rating corresponds to exposure to **one** *Frequently* Job Factor or **four** *Sometimes* Job Factors; and
- a high priority rating corresponds to exposure to **two** *Frequently* Job Factors or **eight** *Sometimes* Job Factors.

Priority scores are generated for each Body Region, for each Task, and for the Overall Job.

3.5.1 Body Region Score. Body Region Scores for each task are determined by totaling the responses to the Job Factor questions for each task. Body Region scores for the job as a whole are determined by averaging scores across tasks. The averaging process was selected by TJI/ADL ergonomists to reflect the beneficial impact of task variety. Consider the following example jobs.

Job A is comprised of just one task: computer work. This task exposes the shoulder/neck to a *high* level of ergonomics risk factors - Body Part Score = 8. Since there is only one task, the Body Region Priority Score is 8, which is a "High" rating. Job B is comprised of two tasks: computer work and filing. This computer work task , which is performed for 5 hours per day, also exposes the shoulder/neck to a "high" level of ergonomics risk factors - Body Part Score = 8. The filing task, which is performed for 3 hours per day, exposes the shoulder neck to a "low" level of ergonomics risk factors - Body Part Score = 2. The average Body Region Priority Score is 5, which is a "Medium" rating.

A comparison of the Body Region Priority Score for each task suggests that Job B is easier on the shoulder than Job A. The "Medium" rating on Job B suggests that, since the employee spends part of the day performing a task (filing), which provides some relief to the shoulder, the overall potential for a shoulder problem is reduced. This is consistent with the ergonomics research literature which indicates that a job designed with task variety should reduce the overall potential for WMD development. Also, since the rating system still indicates that, when computer work is performed, the shoulder is at "high" risk, the technician can be directed to identify controls which reduce exposure to ergonomics risk factors that impact the shoulder during computer work.

While averaging may not always reflect the precise daily physical experience of the employee, it provides the technician with a standardized method for determining the impact of overall daily exposure and how to focus problem-solving efforts in order to achieve the desired impact on employee health and safety. This concept can be referred to as *High-Impact, Precision-Strike* problem-solving.

3.5.2 Task Score. The individual Task Score is determined by selecting the highest numerical body region score for that task. The highest numerical body region score is converted into a high, medium or low rating. The reason: the feeling of fatigue or pain, which are often precursors to WMD development, is not "averaged" throughout the body by the employee. For example, if exposure to a high level of risk factors causes an employee's shoulder to hurt, the employee does not think, "my shoulder hurts, but the rest of my body is OK, so I must be OK." Rather, the employee reports a shoulder problem because that part of the body hurts. Therefore, if the shoulder is exposed to a high level of ergonomics risk factors, the Task Score reflects that most significant exposure.

3.5.3 Overall Job Priority Score. The Overall Job Priority Score, *high*, *medium*, or *low*, is determined by selecting the highest Body Region Priority Score. The basis for this scoring concept is identical to that which was described in section the Overall Priority Rating is used to determine which jobs need the most immediate attention.

3.5.4 Interpretation and Intended Use of the Results. The Overall Job Priority Rating/Score is used to determine which jobs to address first. Task Ratings/Scores are used to determine which task(s) within the job need to be the focus of problem-solving efforts. And finally, the Body Region Scores for each task are used to target the identification of controls for the body parts that are exposed to the highest level of ergonomics hazards. Again, the objective is *Precision-Strike focus, High Impact results*.

4.0 BASIS FOR VALIDATING THE METHODOLOGY

4.1 APPROACH

Testing of the Methodology was completed in two major steps: alpha testing and beta testing.

Alpha testing examined the usability and reliability of the Methodology when used by experienced ergonomists. Beta testing examined the performance of the Methodology when used by non-ergonomists. Test job scenarios were developed containing video and text information for 11 representative administrative tasks. These test job scenarios were used for both alpha and beta testing.

Prior to conducting the alpha testing, the two ergonomists most familiar with the jobs used in the scenarios completed an independent assessment. These findings from the two ergonomists served as a Gold Standard to which the alpha test performance was compared. The purpose of the Gold Standard was to provide an indicator of concurrent validity and to suggest content changes to the scenarios, instructions and checklist.

The factors which were considered when selecting the Gold Standard ergonomists were:

- experience in office ergonomics training, workstation adjustments or modifications, and facility design;
- first-hand knowledge of Air Force administrative jobs; and
- limited involvement in the Level I Methodology.

The ergonomists selected as Gold Standards were J. Nelson and L. Miller. Qualification Summaries are provided in Appendix A. (Note: J. Nelson served as Gold Standard on the JR/PD Survey development project, and L. Miller collected all job data related to the administrative jobs used for alpha and beta testing.) The Gold Standard approach was included in this project even though it was not on the original work plan. The Joyce Institute proposed the approach because it worked well for the project completed for Air Force Space Command, namely the development of the JR/PD survey. The Gold Standard approach was presented to and approved by the COR and HQ AFMC/SGC.

4.2 METHOD

4.2.1 Research Design. It was estimated the five subjects would be sufficient for the alpha test to provide a preliminary evaluation of the guide and to provide guidance for required changes. It was also estimated that ten subjects would be sufficient to demonstrate the utility of the Methodology. The beta testing was then designed to use 10 BEF technicians as subjects. Each subject (five in alpha test, ten in beta test) evaluated each of the 11 Job Scenarios. The Scenarios were administered in random order to control order effects. This was, therefore, a repeated measures design, with multiple

dependent measures. The dependent measures collected for each Scenario were the Task Ratings, the Overall Priority Rating, a recoded Overall Priority Rating (the recoding is detailed in Section 4.3.4), the Shoulder/Neck Overall Priority Rating, the Hands/Wrists/Arms Overall Priority Rating, the Back/Torso Overall Priority Rating, the Legs/Feet Overall Priority Rating, the Head Eyes Overall Priority Rating, and Time to complete the assessment.

4.2.2 Alpha Testing.

4.2.2.1 Subjects. Five ADL/TJI ergonomists participated in the alpha testing. These ergonomists are experienced in the use of assessment tools and ergonomics checklists, although the alpha test was their first time using this specific instrument.

4.2.2.2 Procedure and Apparatus. Each of the ergonomists was provided with the following materials:

- 11 Job Scenarios and corresponding video tape;
- Level I Ergonomics Assessment Checklist (draft 1);
- Checklist Scoring Summary (draft 1);
- Corrective Action List (part of Checklist Scoring Summary);
- Case Study Problem-Solving Matrices (draft 1); and
- User's Instructions (draft 1).

The jobs on which the Job Scenarios were based, were selected to represent a variety of Air Force administrative jobs (e.g., contract specialist) and a variety of risk factor exposures. The Level I Ergonomics Assessment Checklist was used to analyze the job. The Checklist Scoring Summary was used to score the checklist and record results of the pattern-matching process using the 11 Case Study Problem-Solving Matrices. User's instructions were provided to ensure that each ergonomist followed the same procedure for applying the Methodology. The ergonomists commented on the usability of the Methodology components and user's instructions. A second draft of each of the Methodology components was developed to reflect those comments (refer to section 5.4.1, Usability). After alpha testing was completed, a consensus score for each Job and Environmental Factor question from the Level I Assessment Checklist was developed to serve as a testing standard during beta testing.

4.2.3 Beta Testing.

4.2.3.1 Subjects. Ten Air Force personnel were selected to participate in a single-step beta test. These personnel were to be selected to "match" the targeted end-user population: BEF Technician with 2-3 years of experience. Ten personnel were provided and the test was conducted at Kelly AFB. The participants and their experience levels are described in Table 4.1.

Table 4.1
Air Force Personnel for Beta Test

Name	Organization	Previous Ergonomics Training	Experience
Michael Newport	76 MDOS	yes	2 years
William Reid	59 MDW	no	3 years
Patricia Vera	76 MDOS/SGPM	yes	5 years
Joe Zapata	76 MDOS/SGPB	yes	3 years
Karen Fletcher	12 AMDS/SGPB	no	4 years
Richard Glisson	12 AMDS/SGPB	no	15 years
Altadawn Bell	76 MDOS/SGPB	yes	2 years
Jennifer Fox	76 MDOS/SGPM	yes	1 year
Judith McMillen	76 MDOS/SGPM	yes	5 years
Dennis Benzel		yes	1-2 years

Note: Some variation in results was expected between personnel with previous knowledge of ergonomics, particularly those who have had previous training in ergonomics analysis. The test pool of 10 subjects was anticipated to provide sufficient power for testing.

The rationale for selecting ten subjects as the appropriate number was based on the practicalities of conducting the research. The time frame and the budget agreed to for this project permitted only ten subjects' data to be collected and analyzed. The time frame did not permit the Alpha test data to be completely analyzed and used as a basis for determining observed effect sizes. The different nature of the subjects in the Alpha and the Beta tests would have rendered any effect size estimates suspect. Without any reliable estimate of effect size, all rational for estimating sample sizes boils down to: "run as many subjects as you can." However, given the budget and the time frame available for this project, the number of test subjects appears to have been sufficient to demonstrate an adequate level of reliability, sensitivity and validity.

4.2.3.2 Procedure and Apparatus. Each of the beta testers was provided with the following materials:

- 11 Job Scenarios and corresponding video tape;

- Level I Ergonomics Assessment Checklist (draft 2);
- Checklist Scoring Summary (draft 2);
- Corrective Action List (part of Checklist Scoring Summary);
- Case Study Problem-Solving Matrices (draft 2); and
- User's Instructions (draft 2).

The testing was conducted in the following steps: briefing/overview of the Methodology, testing, and outbriefing/focus group.

4.2.3.3 **Briefing/Overview of the Methodology.** The ergonomist/facilitator provided a two-hour briefing using a sample job to demonstrate the Methodology, use of the materials, and process for completing the assessment and patter-matching activity. The results from the sample job are not included in the beta test results.

4.2.3.4 **Testing.** The testing process and materials provided were the same as for the alpha test (with the appropriate revisions). Each beta tester followed the User's Instructions to apply the Methodology to each of the Job Scenarios. The testing process was completed in 2.5 days. Each beta tester was also asked to record the amount of time required to complete both the Level I Ergonomics Assessment Checklist/Checklist Scoring Summary and the pattern-matching/control-identification process for each Job Scenario.

4.2.3.5 **Outbriefing/Focus Group.** Information on usability was obtained by the ergonomist who administered the beta test. The ergonomist obtained comments throughout the testing and conducted a focus group/out-briefing with participants to obtain additional comments after the testing was complete. For more details on the process used to obtain usability/practicality comments, refer to section 4.3.3, Practicality Testing.

4.3 DATA ANALYSIS AND SCIENTIFIC BASIS

The purpose of the data analysis is to show that the design of the Level I Methodology meets the project goals. To do this it is necessary to demonstrate that the Methodology is reliable, sensitive, valid and practical. These concepts are easily defined. A scale is said to be valid if it measures what it is intended to measure. For example, if one needs to know how much force will be required to provide a given acceleration to an object, then weighing the object provides a valid measure, unless it is necessary to consider other gravitational systems. In that case, weight would not be a valid measure of an object's mass. An ergonomics assessment tool, such as the Level I Checklist, should measure some aspect of human health, comfort or performance in order to be a valid measure.

Reliability, on the other hand, refers to the accuracy and the repeatability of the measurement of a variable. The reliability of an instrument is the foundation for the other concepts. An instrument must be reliable in order to be valid, since one can not be sure that the "valid results" obtained one time will be repeated. In our weight/mass example,

asking people to estimate the mass of an object by picking it up would be a valid measure, but would have much less reliability than using an electronic scale. An electronic scale would be very reliable, having excellent repeatability and accuracy. However, if the goal was to evaluate the beauty of an object, rather than its mass, then the scale would not be valid, even though it would be highly reliable.

Sensitivity refers to how well the scaling levels of a tool reflect the levels that exist. Continuing our weight/mass example, if the electronic scale measured (with reliability and validity) the weight of objects in pounds, but you were interested in differences in objects weighing less than ounce, then the scale would not have sufficient sensitivity to identify the differences. In order to have sufficient sensitivity, one would need a scale that reported much finer increments.

Practicality identifies the usefulness and usability of an instrument. Continuing with our weight/mass example, if our electronic scale reported weights with sufficient sensitivity, it may still need to meet constraints such as speed of calibration and portability in order to be a practical scale for its intended application.

Data analysis was accomplished using Microsoft Excel v7.0 and SAS v6.11.

4.3.1 Reliability Testing. Reliability testing of assessment tools generally takes one of two forms, test/re-test reliability and inter-rater reliability. Test/re-test reliability defines how well the same person will achieve the same results using a tool at different times. Inter-rater reliability defines how well different people will agree on the results.

Several techniques have been used and reported for inter-rater reliability testing with ergonomic assessment tools. The coefficient of variation was used in one study [9] with scores of less than 20 percent for most measures. Multiple regression has also been used [9] with a finding of no statistically significant differences between raters supporting reliability. Kemmlert [3] found weighted averages of Kappa ranging from 0.24 to 0.44 and a percent agreement often above 70 percent. Keyserling, Stetson, Silverstein and Brouwer [8] used inter-rater agreement percentages as a part of their validation. There is little consensus on the best methods for demonstrating inter-observer agreement (Meister, 1985).

Individual questions were evaluated for reliability by calculating intraclass correlation and Kappa statistics for the alpha and beta tests (Section 4.2.2 and 4.2.3). These statistics were chosen because they represent the most accurate method for testing reliability while controlling for the effects of chance. The data meet all of the assumptions for Kappa (Cohen, 1960; Brennan & Prediger, 1981) which are that :

- the objects categorized are independent;
- the raters operate independently; and
- the categories are independent, mutually exclusive, and exhaustive.

Since it would be expected that a certain amount of agreement would occur by chance, like having 50% correct on a true/false test, the Kappa statistic reports agreement after chance has been removed. A Kappa value can be interpreted as a percent of agreement, for instance a Kappa of 0.75 indicates an agreement rate of 75% after chance has been removed.

In terms of the true/false test scenario presented previously, if a test had 100 questions it would be hard to predict the whole test score based on knowledge that 7 of 10 questions were answered correctly. The prediction of whole test scores would improve with knowledge that 35 of 50 questions were answered correctly. Although the proportion of agreements (test answers with correct answers) is the same in each case, in the second scenario more accurate estimates can be made. The variance of Kappa is a numerical reporting of this prediction accuracy. As a means of comparison, assuming an equal overall ratio of true and false responses, the Kappa value for each of the above scenarios would be 0.40.

For interpreting the Kappa values, the following interpretations were used, consistent with those suggested by Landis and Koch (1977) and as shown in Table 4.2:

Table 4.2
Kappa Value Interpretation

Kappa Values	Interpretation
0.81 to 1.0	Almost Perfect
0.61 to 0.80	Substantial
0.41 to 0.60	Moderate
0.21 to 0.40	Fair
0.0 to 0.20	Slight
< 0.0	Poor

The scores (item level, body region level, risk rating and solution selection) from both the alpha and beta test sessions were analyzed independently using the Intraclass Correlation Coefficient (ICC) and Kappa statistics. The ICC is presented in combination with the Kappa Values. The ICC is equal to a weighted Kappa in which the differences are squared. By squaring the differences, disagreements of a larger magnitude i.e., *Never* vs. *Frequently*, result in a greater degree of disagreement. Since the ICC is equal to a weighted Kappa the same interpretation of ICC as described for Kappa can be applied. These analysis are described in detail in sections 3.2 and 3.5.8 of this document.

4.3.2 Sensitivity Testing. Measures of assessment tool sensitivity have not generally been reported in the ergonomics assessment tool literature. Sensitivity is demonstrated by how well the tools can distinguish risk factor levels from one job to

another. Discriminant analysis was selected as the primary method for the sensitivity analysis. Discriminant analysis is a multivariate technique that uses both grouping data (in this case, the Gold Standard judgment of the risk level of each Scenario) and the measured variables, and constructs linear combinations of the measured variables to create the best possible categorization to match the known grouping. The discriminant analysis can be conducted many ways, simultaneous and stepwise analyses were conducted for this project. One major advantage for use of discriminant analysis is that, if only the statistically significant discriminant functions are used, then it is more likely to find increased sampling stability that if all of the data was used for the "best' classification (Tatsuoka, 1974). For this analysis, each Scenario was rated as High, Medium or Low Risk, based on the Gold Standard evaluation. This categorization was used as the grouping or classification variable for discriminant analysis. The subject's Overall Priority Rating and the five Body Region Priority Scores (Shoulder/Neck, Hands/Wrists/Arms, Back/Torso, Legs/Feet, and Head/Eyes) were used as the predictor variables. Two types of discriminant analysis were conducted, simultaneous and step-wise.

4.3.2.1 Validity. A variety of methods have been used to establish the validity of ergonomic assessment procedures. Predictive validity has been suggested through comparisons with incidence rate [6] and with discomfort ratings [7]. Any predictive validity measures for simple assessment techniques are subject to confounding variables which could greatly reduce power. Concurrent validity has been supported through comparing expert ratings on two different techniques [3] and by comparing novice users of a simple technique with expert users of a more detailed Methodology [8]. Content validity has been reported as an item match with scientific literature [3].

4.3.2.1.1 Content Validity. The content validity was based on using referenced criteria to select questions during tool development. Kemmlert [3] submits a measure of content validity for the PLIBEL method. Scientific literature was reviewed to provide references for each item in PLIBEL. The primary approach for assessing content validity for the Level I Checklist was to provide support in the literature (particularly validated assessment tools) for all Job Factor questions and scaling approaches.

4.3.2.1.2 Concurrent Validity. The primary method for assessing the concurrent validity of the evaluation was to compare the alpha and beta test evaluations with the Gold Standard. The Gold Standard results were compared to the alpha and beta results using *t tests.* The *t test* was selected because it is known to be robust to violations of most of the distributional assumption and with only 5 alpha and 10 beta subjects, it is unlikely that the data will meet the assumptions of the *t test*. However, the *t test* still provides a reliable indication of the differences between the alpha or beta test scores and the Gold Standard. Furthermore, because most assumption violations would cause the *t test* to be liberal, in this particular case that would work against the demonstration of agreement between the test scores and the Gold Standard. The Joyce Institute is unaware of any statistic that would be more accurate in describing this particular situation of comparing a set of

"correct" answers with data collected from a number of subjects on each of the 11 Scenarios. The *t test* is simple, well known, well understood, and easily communicated.

Validity was also evaluated using two graphical methods. These two evaluations were based on the argument that, because each Scenario was different, a valid Level I Checklist result would indicate different response patterns for the Case Study Problem-Solving Matrices selected and for the Body Region Priority scores. Also, for the Case Studies selected, the response patterns should show a clustering within a Scenario as well as differences between Scenarios.

4.3.2.1.3 Predictive Validity. Predictive validity was assessed by comparing a body part risk ratings from the beta test with body part rankings based on operator discomfort ratings. A Pearson correlation was performed. Power was expected to be weak for this analysis because of the number of outside factors that can influence discomfort and the ratings of discomfort, as well as the small sample size of discomfort data. Using an alpha of 0.10, power estimates are less than 0.3 which suggests that a failure to find statistical significance should not be interpreted as a lack of predictive validity. The Pearson correlation was chosen instead of the Spearman since one of the variables was interval in nature and power was anticipated to be weak in any case. The failure to find significance in this relationship negates any concerns about treating ordinal data as interval data for this analysis since any effect would lead to liberal conclusions.

In order to attain reasonable power with an alpha of 0.05, a sample size of nearly 100 jobs would be required or jobs would need to be selected which differed greatly in musculoskeletal stress levels (which would demonstrate predictive validity but not sensitivity). In spite of power short comings, the predictive validity was assessed and reported.

4.3.3 Practicality Testing. While the practicality of the Methodology is perhaps the most important consideration, it is also the most difficult to quantify in a short-term test. The solid test of practicality is how frequently the tool is applied in examining workstations and the results obtained through the changes. In the shorter-term, several measures were used to examine the practicality of the tool. The usability comments were tabulated, with the assumption that a highly useable tool is more practical than other tools. The descriptive statistics of time requirements were compared to the criteria established, with the assumption that an effective tool that can be completed within the time suggestions has some practicality. The overall agreement regarding solution options, based on Kappa, was calculated and reported, based on the assumption that a method which leads to consistent solution recommendations is practical. While none of these measures prove practicality, positive results in all these areas would suggest that technicians will find that the tool is a practical one to use.

4.3.4 Data Reduction and Recoding. Data were entered into an Excel spreadsheet and where checking and coding were conducted. The data were written to an

ASCII file and modified using a text word processor for input to SAS. Three SAS datasets were created, one for each of the alpha and beta samples with one logical record per subject, and one for the beta sample with 11 logical records per subject (one record for each Scenario). The single record per subject datasets were used for the reliability analyses, and the multiple record per subject dataset were used for the discriminant analysis. No multiple record per subject dataset was generated for the alpha test because it was judged that there were too few subjects (5) to permit a meaningful discriminant analysis.

The comparisons between the Gold Standard results and the alpha and beta tests were conducted on recoded values for the Overall Priority Rating. The Gold Standard Ratings were recoded into a Low, Medium or High rating, which was coded as 1, 2, or 3. The alpha and beta test Overall Priority Ratings were also recoded into the same Low, Medium or High rating, also coded as 1, 2, or 3. The coding scheme for the Gold Standard is shown in Table 4.3.

Table 4.3
Gold Standard Recoding Scheme

Original Rating	Recoded Rating
0 – 2	1
3 – 4	2
5	3

The coding scheme for the alpha and beta tests is shown in Table 4.4.

Table 4.4
Alpha and Beta Test Recoding Scheme

Original Rating	Recoded Rating
0 – 3	1
4 – 7	2
8 +	3

4.3.5 Summary of Statistical Selection Rationale. Preliminary data screening was not conducted to evaluate variable distributions. For most parametric statistics, the distributional tests for normality, etc., are more sensitive than are the parametric tests themselves. The parametric tests are quite robust to violations of the distributional assumptions, especially if there are equal number of subjects in each group. Furthermore, the design ensured that the assumptions of the primary statistic for reliability and validity were met. The data meet all of the assumptions for Kappa [35, 36]as initially described in the Work Plan, which are that:

- the objects categorized are independent;
- the raters operate independently; and
- the categories are independent, mutually exclusive, and exhaustive.

As discussed above, much of the data collected for this project was recoded to be on a *High, Medium* or *Low* scale. These data therefore are scaled as at least ordinal data, because we know that *High* is larger than *Medium*, and *Medium* is larger than *Low*. However, while the scale itself is only a three level scale, clearly the data represented have more range than that. Furthermore, the original data can lie on a continuum between *High* and *Low*. therefore, for the purposes of illustrating the observed data, and for some of the exploratory type of analyses, means and standard errors were calculated, graphed and used in analyses. In many cases, this resulted in values intermediate between *High, Medium* and *Low* levels being reported, and occasionally in error bars extending above the *High* scale value; the reader is urged to regard these as approximating the central tendency and variability of the true underlying variable. Importantly, the critical analyses, the Kappa analyses and the discriminant analyses, used these data as representing a categorical scale.

This research project was designed to use the power of a repeated measures design to provide as much value-added information as possible on the Level I Methodology. As with any other research project, additional testing with more subjects, on additional Scenarios would yield increased precision, with a commensurate increase in cost and testing time. The selection of a data analysis strategy is a process that depends on may factors. Minor changes in the research methodology, designed to improve the precision of the study, can necessitate substantial changes in the analysis. The data analyses for this project were finalized after the research methodology was fully developed, following extensive consultation with senior academic research scientists to provide and accurate, concise, and clear portrayal of the results. In addition to Kappa analysis described in the Work Plan, additional analysis, included discriminant function analysis was also conducted to evaluate the use of Guide and determine how reproducible the user results matched the responses of the Gold Standard Ergonomists. This additional analysis was accomplished with the consensus of the Air Force and resulted in a better product. The analysis strategy used in this effort was a value added approach. While there are other data analysis techniques which could have been applied, the results provide an adequate initial basis for evaluating the utility and practicality of the Level I Methodology.

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5.0 RESULTS

5.1 RELIABILITY

The reliability results from the alpha and beta tests are consistent. The mean value of Kappa for individual questions is essentially identical between the test groups (alpha = 0.22, beta = 0.23). The rates compare well with the range of weighted averages of Kappa (0.24 to 0.44) found by Kemmlert [3]. The Kappa values obtained are nearly identical between the alpha and beta tests or 14 of the 25 variables. These results indicate a consistent and statistically significant agreement on individual question (this agreement is classified in the slight to fair range). The ergonomists and the technicians obtained similar levels of agreement on individual questions as have been found in research studies using other ergonomics assessment tools. Furthermore, the ergonomists and technicians demonstrated agreements on the overall scores for the jobs.

5.1.1 Item Level Agreement. The Kappa and Intraclass Correlation Coefficients (ICC) were calculated on each question to determine the agreement between raters for both the alpha and beta test sessions. The ICC provides an agreement value equal to the weighted Kappa, with the differences squared. The ANOVA F-statistic provides a test of significance for the ICC (Bartko, 1966). A generalized, simple Kappa appropriate for multiple raters and response categories (Bartko & Carpenter) is reported for item agreement. The variance of Kappa and the probability of the Kappa are reported for each question and the response rates from the combination of the Sometimes and Frequently categories are also reported.

5.1.1.1 Alpha Test. The general level of agreement between ergonomists using the Level I Checklist is present in Table 5.1. The agreement rates, not corrected for chance, for the alpha test questions ranged between 40% and 86% for those questions with sufficient response rates of risk factor presence. The desired level of agreement is 0.6 to 0.7, suggesting that after the effects of chance are removed ergonomists would agree at least 60% of the time. On the whole, the questions did not approach this level of agreement. The utility of questions with lower than a 10% response rate requires careful consideration particularly if the question also displayed low agreement. Questions 6, 11, and 26 fit this pattern. Kemmlert [3] found agreement Kappa values in the fair to moderate range for individual questions. A total of 10 of 25 questions had similar agreement rates in this study.

5.1.1.2 Beta Test. Questions with response rates of less than 10% were interpreted cautiously, and considered for removal from the Level I Checklist due to the apparent limited applicability of the question to typical administrative jobs. However, the ergonomists decided that the question should remain because the Job Factors represented are typical of many administrative areas. To remove the items at this time would potentially limit the applicability of the tool to a wide range of work situations that may

not have been observed during the site visits. Questions with low response rates were numbers 3, 5, 17, and 21. Table 5.2 shows results for the beta tests.

A total of 10 of the 26 questions fell in, or above, the range of Kappa values found in the checklist study by Kemmlert [3]. The questions which fell in this range are numbers 4, 5, 6, 16, 17, 20, 21, 22, 23, and 24. Nearly all questions fall in the descriptions of slight to fair agreement [37]. Although no questions met the goal criteria for Kappa of 0.6 to 0.7, nearly all the questions still have statistically significant agreement.

Table 5.1
Testing of the Item Agreement Among Ergonomists for Alpha Test

Question	Response Rate	Kappa	K Var	K p<	ICC	ICC p <
Question 1	40%	0.08	0.012	n.s.	0.11	0.052
Question 2	37%	0.07	0.005	n.s.	0.16	0.016
Question 3	10%	-0.01	0.203	n.s.	0.18	0.009
Question 4	10%	0.41	0.160	n.s.	0.29	0.000
Question 5	8%	0.47	0.205	n.s.	0.35	0.000
Question 6	9%	0.28	0.180	n.s.	0.19	0.005
Question 7	71%	0.16	0.003	0.002	0.18	0.008
Question 8	43%	0.12	0.009	n.s.	0.26	0.000
Question 9	40%	0.07	0.011	n.s.	-0.04	n.s.
Question 10	53%	0.18	0.004	0.007	0.24	0.001
Question 11	10%	0.09	0.141	n.s.	-0.03	n.s.
Question 12	23%	0.21	0.042	n.s.	0.19	0.005
Question 13	39%	0.18	0.012	n.s.	0.32	0.000
Question 15	16%	0.27	0.080	n.s.	0.14	0.024
Question 16	57%	0.08	0.003	n.s.	0.15	0.020
Question 17	13%	0.32	0.102	n.s.	0.40	0.000
Question 18	6%	0.47	0.268	n.s.	0.48	0.000
Question 19	30%	0.17	0.024	n.s.	0.32	0.000
Question 20	18%	0.08	0.062	n.s.	0.12	0.049
Question 21	10%	0.50	0.142	n.s.	0.62	0.000
Question 22	7%	0.53	0.232	n.s.	0.49	0.000
Question 23	56%	0.29	0.004	0.000	0.38	0.000
Question 24	38%	0.30	0.011	0.005	0.37	0.000
Question 25	26%	0.20	0.033	n.s.	0.34	0.000
Question 26	11%	-0.02	0.127	n.s.	-0.01	n.s.

Table 5.2
Testing of the Item Agreement Among End Users (Beta Testers)

Question	Response Rate	Kappa	K Var	Kappa P<	ICC	ICC P<
Question 1	40%	0.03	0.003	n.s.	0.03	n.s.
Question 2	53%	0.16	0.001	0.001	0.23	0.001
Question 3	7%	-0.01	0.053	n.s.	0.00	n.s.
Question 4	17%	0.38	0.017	0.004	0.39	0.001
Question 5	7%	0.45	0.056	n.s.	0.33	0.001
Question 6	10%	0.31	0.033	n.s.	0.34	0.001
Question 7	67%	0.10	0.001	0.001	0.14	0.001
Question 8	49%	0.10	0.001	0.009	0.21	0.001
Question 9	44%	0.16	0.002	0.001	0.23	0.001
Question 10	56%	0.21	0.001	0.001	0.30	0.001
Question 11	13%	0.09	0.02	n.s.	0.01	n.s.
Question 12	33%	0.11	0.004	n.s.	0.15	0.001
Question 13	32%	0.16	0.005	0.02	0.30	0.001
Question 14	27%	0.17	0.007	0.04	0.21	0.001
Question 15	46%	0.16	0.002	0.001	0.20	0.001
Question 16	10%	0.52	0.032	0.004	0.20	0.001
Question 17	6%	0.59	0.065	0.02	0.60	0.001
Question 18	39%	0.10	0.003	n.s.	0.12	0.001
Question 19	22%	-.02	0.01	n.s.	-.01	n.s.
Question 20	11%	0.54	0.03	0.002	0.58	0.001
Question 21	7%	0.55	0.04	0.01	0.58	0.001
Question 22	69%	0.23	0.001	0.001	0.32	0.001
Question 23	58%	0.44	0.001	0.001	0.52	0.001
Question 24	43%	0.28	0.002	0.001	0.35	0.001
Question 25	15%	0.14	0.02	n.s.	0.15	0.001
Question 26	17%	0.06	0.02	n.s.	0.09	0.007

The results from the alpha and beta tests are consistent. The mean value of Kappa for each is essentially identical (alpha = 0.22, beta = 0.23). The rates compare well with the range of weighted averages of Kappa (0.24 to 0.44) found by Kemmlert [3]. Furthermore, the Kappa values obtained are nearly identical between the alpha and beta tests for 14 of the 25 variables. These results indicate a consistent, and statistically significant, slight to fair agreement.

5.1.1.3 Beta Test vs. Alpha Test Consensus Scores. The responses on the beta test were compared against a consensus answer sheet developed during alpha testing. The primary purpose of this comparison was to identify any questions that were answered consistently wrong by the beta test subjects. The percent agreement was selected for this comparison instead of the Kappa because the chance correction of Kappa might mask

otherwise substantial percent corrects. For instance, in question #3 the beta test subjects answered correctly 89% of the time, but if a Kappa agreement was calculated this agreement would be reported as .15 because of the chance correction. Across all questions and Scenarios the beta test subjects agreed with the consensus 67% of the time. Only question #22 was an outliner for low agreement, with a score of 24%. In this instance, beta test subjects were more likely to assign ergonomic risk than the ergonomists. Nine of the 26 questions had agreement of 80% or more with the alpha consensus, indicating an overall consensus rate of 35% which falls within the range of the consensus rates (35% to 62%) obtained by Kemmlert [3].

5.1.2 Overall Score Agreement

5.1.2.1 Alpha Test. The overall reliability of the Level I Checklist scores and ratings from the alpha test session was measured in several ways. First, the Overall Priority Ranking was used to calculate an Intraclass correlation statistic [39] for the 11 Scenarios by 5 raters matrix. The calculated value was .088 ($F_{10,42}$=1.97, $p < .051$). This result indicates that there was a marginally significant reliability for the alpha test, on the original Overall Priority Rating. In other words, the ergonomists agreed more often than would be expected due to chance.

In addition, both an ICC and generalized Kappa statistic [39] were calculated for the recoded Overall Priority Rating. Neither of these were statistically significant (ICC = .033, $F_{10,42}$=1.34, $p < .242$; Kappa = .134, $p < .126$).

5.1.2.2 Beta Test. The same statistics used in the alpha test phase were calculated for the beta test data. The results were similar with a non-significant ICC (ICC = 0.086, $F_{10,99}$=1.34, $p < 0.242$) for the original Overall Priority Rating variable, and a non-significant Kappa (0.059, $p < 0.12$) for the recoded Overall Priority Rating variable. The ICC for the recoded Overall Priority Rating variable, however, was statistically significant (ICC = 0.086, $F_{10,99}$=3.48, $p < 0.001$).

Statistical significance for agreement in both the alpha and beta test phases indicates that the agreement obtained was better than would have been expected due to chance. Practical significance suggests that the reliability agreement is slight, with chance corrected agreement rates between 6% and 13%.

5.1.2.3 Alpha - Beta Comparison. Figure 5.1 compares the Alpha and Beta test scores for the original Overall Priority Rating variable, and shows that there were no significant differences between the Alpha and the Beta tests.

Figure 5.1
Alpha & Beta Test Scores

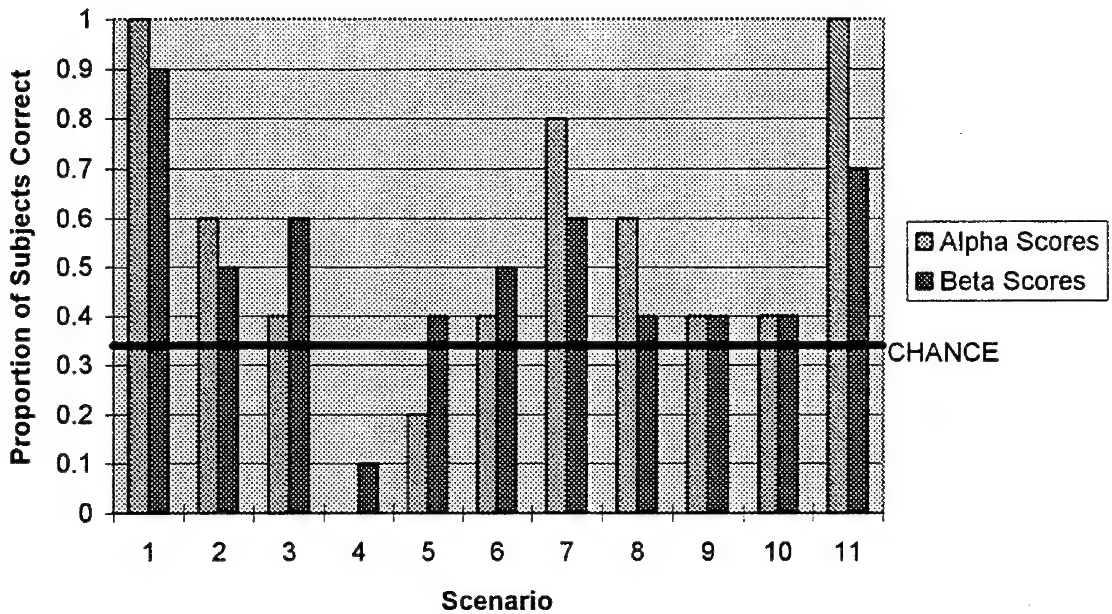


Table 5.3 shows the mean differences, between values and probabilities for the Alpha vs. Beta comparison. Figure 5.2 shows the recoded Alpha and Beta scores and the Gold Standard scores. On average, the technicians identified Overall Priority Ratings that were not consistently different than those ratings obtained by ergonomists.

Table 5.3
Comparison of Alpha vs. Beta Test for Overall Priority Rating

Scenario	$\alpha - \beta$ Difference	t Value	*p* <
1	3.4	0.04	0.965
2	-1.9	0.39	0.702
3	0.5	0.87	0.402
4	-0.5	0.77	0.459
5	3	0.33	0.744
6	0.1	0.96	0.358
7	1.2	0.70	0.497
8	-1.6	0.70	0.498
9	-1.95	0.41	0.684
10	0.5	0.77	0.456
11	3.9	0.31	0.762

Figure 5.2
Gold Standard vs. Alpha & Beta Tests

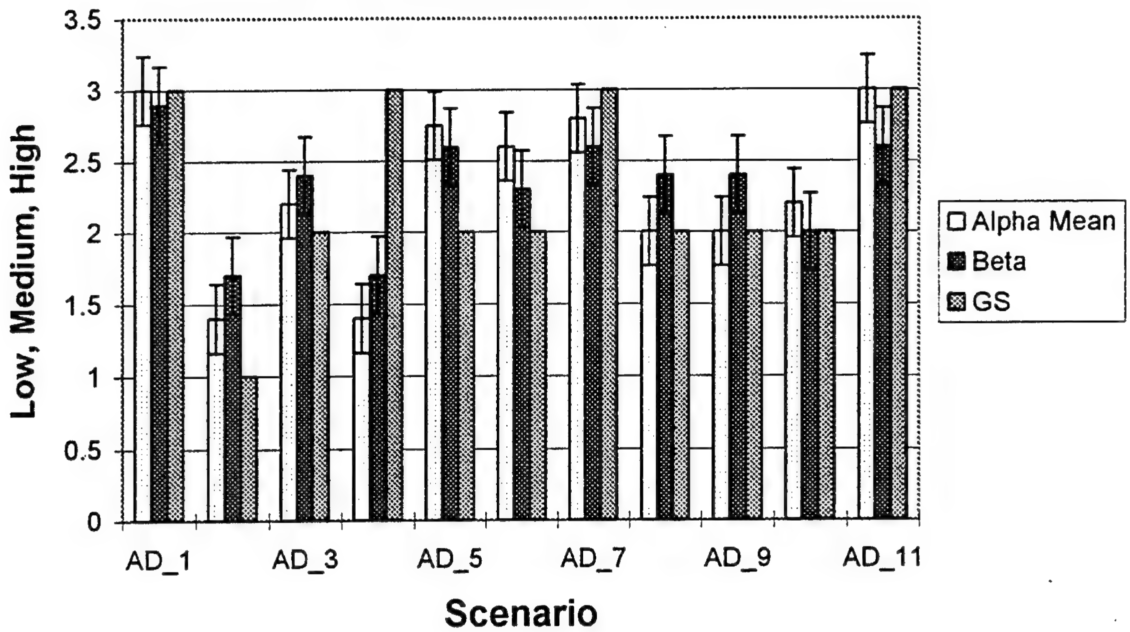
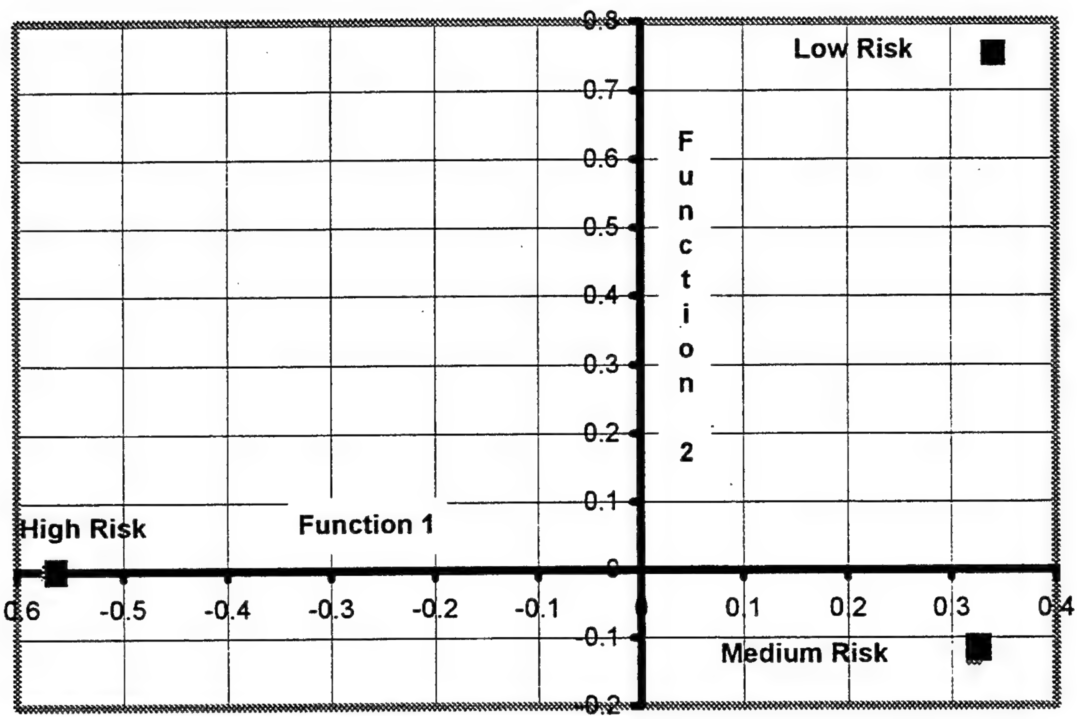


Figure 5.3
Discriminant Analysis for Beta Test



5.2 SENSITIVITY

The stepwise discriminant analysis resulted in one significant discriminant function ($F_{4,212}$ = 4.876, p <0.001), and used the Legs/Feet and Head/Eyes Body Region Priority scores as predictors. The simultaneous discriminant analysis using all 6 variables also resulted in one significant discriminant function. Figure 5.3 presents a graph of the mean scores of the High, Medium and Low Risk Scenarios, as discriminated by the first ($F_{12,204}$ = 2.158, p <0.02) and second ($F_{5,103}$ = 1.320, *ns*) discriminant functions for the simultaneous analysis. It is clear from Figure 5.3 that function 1 discriminates between the High Risk Scenarios and the Low or Medium Risk Scenarios. Function 2, which is *not* significant, discriminates between the Low Risk scenario and the Medium or High Risk Scenarios.

5.2.1 Discriminant Analysis Discussion. While it may seem odd that the Overall Priority Rating did not figure in to the stepwise prediction functions, examination of the correlation matrix indicates that all of the predictor variables are highly correlated. This means that it does not really matter which variable is actually used, because the variables are so highly related. The correlation between the Legs/Feet and Head/Eyes scores is the only non-significant relationship, which suggests that those two variables are measuring different things (refer to Table 5.4).

Table 5.4
Beta Test Correlation Matrix for Job Factor Ratings

Variable correlation *p*	Overall	Priority Rating Shoulder / Neck	Priority Rating Hand/ Wrist/ Arm	Priority Rating Back	Priority Rating Legs	Priority Rating Head
Overall	1.00 0.0					
Priority Rating Shoulder/Neck	0.655 0.0001	1.00 0.0				
Priority Rating Hands/ Wrists/ Arms	0.923 0.0001	0.536 0.0001	1.00 0.0			
Priority Rating Back/Torso	0.545 0.0001	0.712 0.0001	0.444 0.0001	1.00 0.0		
Priority Rating Legs/Feet	0.420 0.0001	0.593 0.0001	0.379 0.0001	0.574 0.0001	1.00 0.0	
Priority Rating Head/Eyes	0.549 0.0001	0.399 0.0001	0.386 0.0001	0.379 0.0001	0.175 0.067	1.00 0.0

The conclusion that can be drawn from this analysis is that there is a significant relationship between the evaluations from the Air Force BEF technicians and the Gold Standard evaluation, and that the Level I Ergonomics Assessment Checklist Analysis can significantly and correctly distinguish between Scenarios that were judged by the Gold Standard experts to be of High or Medium Risk for ergonomic risk factor exposure. The discriminant functions primarily separate the Medium from the High Scenarios, which is probably the most important discrimination to make. However, this conclusion is affected by the fact that there was only one scenario that was rated *Low* by the Gold Standard, so one would expect that there would be less accuracy in predicting the Low Scenarios.

5.3 VALIDITY

5.3.1 Content Validity. There is a strong scientific basis for the inclusion of all the job factor questions present in this analysis. All 30 job factor questions are were derived from peer reviewed journals, established technical books, or proposed standards. Each source has been identified as a potential WMD risk factor and/or cause of localized fatigue and discomfort (see Section 1.3.2.2 for a complete listing of references). Fifteen of the 30 questions were drawn from analysis methods for which validity and reliability was assessed.

The list of job factor questions has been judged to be complete for administrative tasks. At least 32 individual analysis methods were evaluated as a part of the literature review process. All risk factor-based questions identified in the 32 methods was considered for inclusion in order to ensure that the list of job factor questions was complete.

The question/response structure (i.e., postural deviations or forces over a period of exposure) is based on a well-established model of how damage accumulates (see Section 1.3.2.3). Several existing analysis methods [26, 9] which use this basic model have been validated.

5.3.2 Concurrent Validity

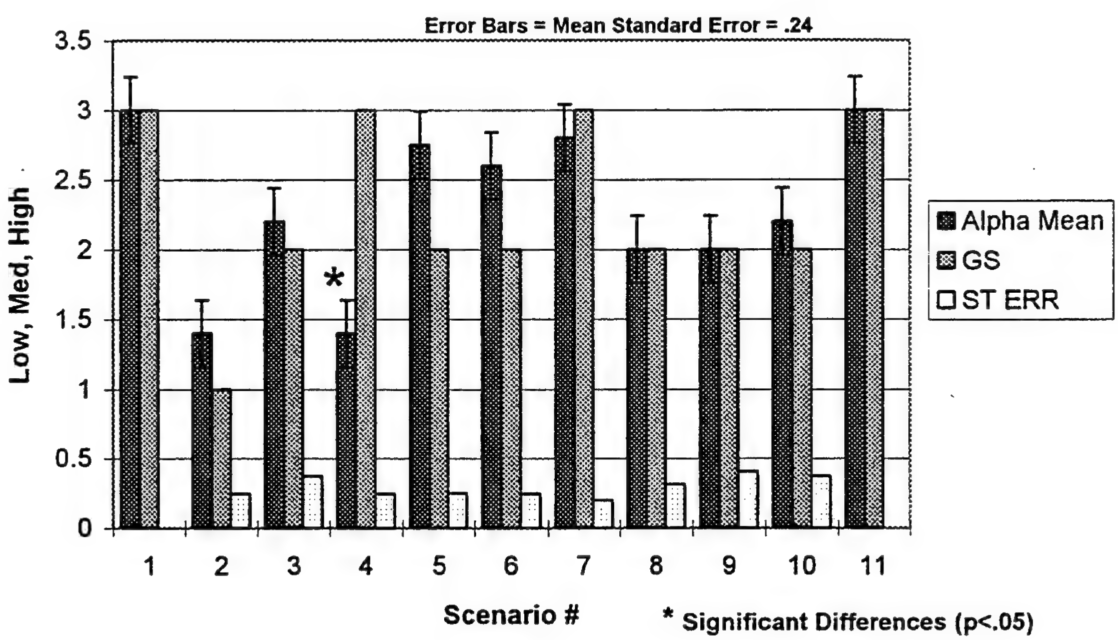
5.3.2.1 Alpha Test. Table 5.5 illustrates the agreement between the Alpha test results and the Gold Standard. As can be seen from Figure 5.4, there was very close agreement for most of the Scenarios. Scenario 4 was significantly different from the Gold Standard. The differences found for Scenarios 5 and 6 were marginal, and may well be an artifact of the scoring method used to determine the High, Medium and Low ratings: both the Gold Standard results and the Alpha test results were close to the borderline between Medium and High, but on different sides of the line. This scoring method therefore may have exaggerated the differences for these two Scenarios. There seems to be a genuine difference; however, between the Gold Standard and the Alpha test results for Scenario 4.

The discrepancy between the Gold Standard and Alpha test results for Scenario 4 can be traced to several key factors:

- the characteristics of the job and Job Factors in Scenario 4;
- the design of the checklist scaling approach;
- the checklist scoring; and
- expert scoring tendencies for Gold Standard.

First, Scenario 4 contains one extreme job factor (as opposed to many Job Factors). In this Scenario, the employee's head was continuously tilted up and the neck was twisted due to the location of the monitor. Aside from this major job factor, there are few other Job Factors of significance.

Figure 5.4
Gold Standard vs. Alpha Overall Rating



Second, the Level I Checklist was designed so that the maximum score that can be obtained for a single Job Factor is 4. This produces a priority rating of *Medium*. The philosophy of the Checklist design is that any job which scores a *Medium* or *High* should be considered for corrective actions in order of priorities established by the priority scores.

Third, the scoring of the overall job tends to smooth the effect of a single high score for one task if the scores for other tasks are less.

Fourth, the ergonomists may be pre-disposed to consider that a job has a high level of musculoskeletal stress based on the presence of only one job factor (e.g., twisting and bending the neck) over a substantial daily duration.

These factors together caused the alpha test ratings to be substantially lower than the Gold Standard ratings.

Table 5.5
Comparison Between Alpha Test and Gold Standard, by Scenario, for the Overall Priority Rating Score

Scenario	Mean Difference	t Value	*p* <
1	0.00	0.00	1.000
2	0.40	1.46	0.204
3	0.20	0.48	0.653
4	-1.60	-5.84	0.002
5	0.75	2.60	0.060
6	0.60	2.19	0.080
7	-0.20	-0.89	0.412
8	0.00	0.00	1.000
9	-0.75	-1.36	0.246
10	0.20	0.48	0.653
11	0.00	0.00	1.000

5.3.2.2 Predictive Validity. As an additional indication of the validity of the Level I Methodology, Figure 5.5 illustrates the number of Alpha test subjects who selected each Case Study as relevant to a Scenario. If the Methodology is a valid tool, it would be expected that it would lead to substantial agreement on the Case Studies selected, and that the different Scenarios would result in different Case Studies being selected. Figure 5.5 illustrates that this was indeed the case. Finally, the Level I Methodology, if valid, would also be expected to generate different scores for the 5 Body Region Priority Scores, for each Scenario. Figure 5.6 illustrates that this was the case, lending additional support for the conclusion that the Level I Methodology is a valid process for assessing and identifying controls to ergonomic concerns.

Figure 5.5
Alpha Test Case Study Agreement

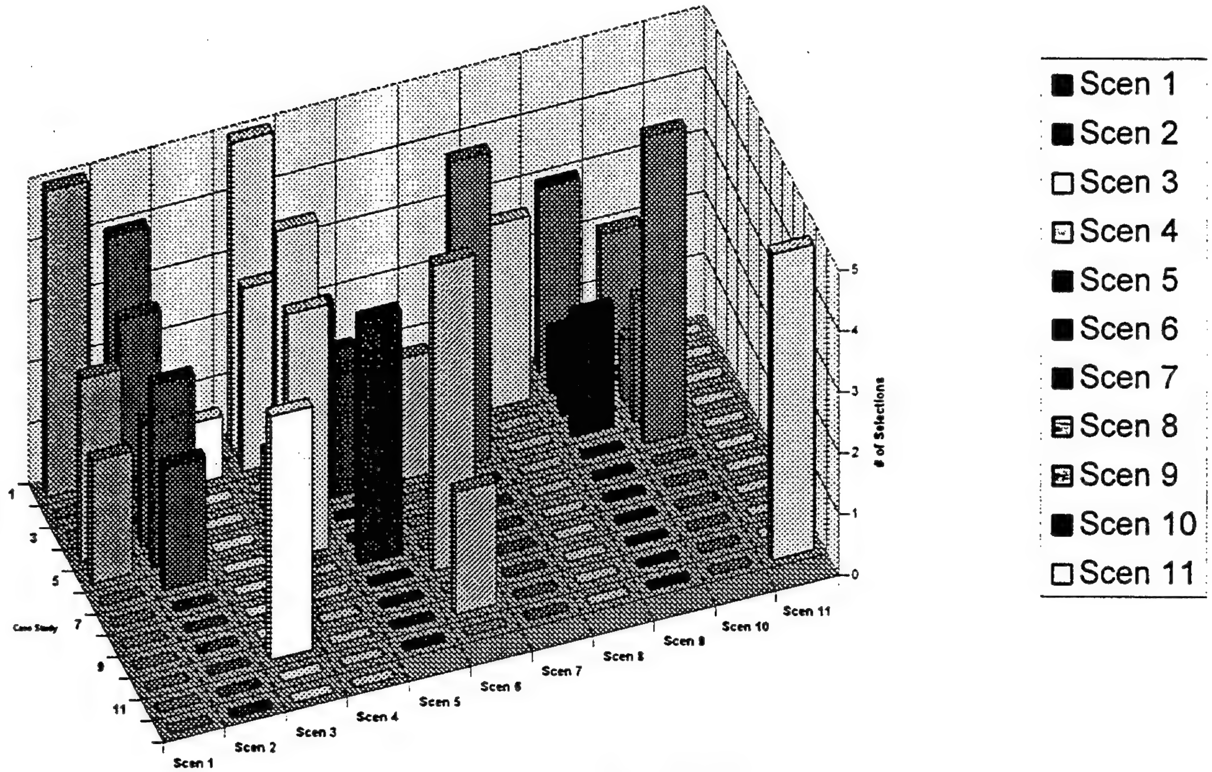
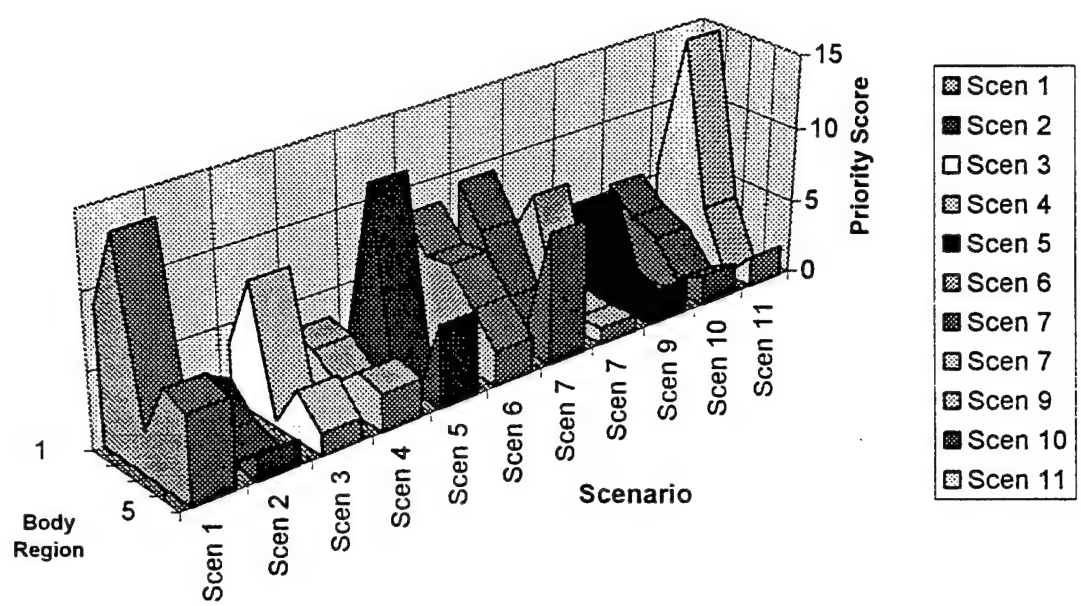


Figure 5.6
Alpha Test Body Region Priority Scores



5.3.2.3 **Beta Test.** Table 5.6 illustrates the agreement between the beta test results and the Gold Standard. As can be seen from Figure 5.7, there is substantial agreement for most of the Scenarios. Scenarios 2, 3, 5 and 7 showed relatively small, but statistically significant differences between the Beta test and the Gold Standard. Again, as in the alpha test, there seems to be a large difference between the Gold Standard and the beta test results for scenario 4. The explanation for the differences for Scenarios 4 and 7 is the same as for the Alpha test (see Section 5.3.2.1).

The discrepancy between the Gold Standard and Beta test results for scenarios 2, 3, and 5 can be traced to several key factors:

- multiple job factors in scenarios 2, 3, and 5;
- job factor emphasis on the shoulder, hands, wrists, and arms in scenarios 2, 3, and 5;
- scoring tendencies of less experienced Beta testers;
- expert scoring tendencies for Gold Standard.

First, scenarios 2, 3, and 5 have multiple job factors. The checklist tends to give a higher score for those jobs which have several moderate intensity job factors than those jobs that have one or two high intensity job factors.

Second, scenarios 2, 3, and 5 had job factors focusing on the shoulder and the hands/wrists. The checklist tends to give higher scores for those jobs which have job factors related to the shoulder and the hands/wrists. This is due to the fact that there are multiple job factor questions for these body regions.

Third, Beta test subjects seemed to have difficulty distinguishing between job factors which were present *Frequently* versus job factors which were present *Sometimes* or even *Occasionally*. If the job/task was performed for greater than 4 hours per day, Beta test participants tended to score all job factors as “Frequently” even if the job factor only occurred occasionally.

Fourth, the ergonomists may be pre-disposed to consider a job with several low-to-moderate intensity job factors as a moderate level of musculoskeletal stress.

These factors together caused the Beta test ratings to be substantially higher than the Gold Standard ratings.

Table 5.6
Comparison Between Beta Test Technicians and Gold Standard, by Scenario, for the Overall Priority Rating Scores

Scenario	Mean Difference	t Value	*p* <
1	-.1	-1.0	.344
2	0.7	2.69	.025
3	0.4	2.44	.037
4	-1.3	-6.09	.001
5	0.6	3.67	.006
6	0.3	1.4	.193
7	-.4	-2.45	.037
8	0.4	1.81	.104
9	0.4	1.81	.104
10	0	0	1.0
11	-.4	-1.81	.104

5.3.2.4 Case Study Selection. As an additional indication of the validity of the Level I Methodology, Figure 5.8 illustrates the number of Beta test subjects who selected each case study as applicable to a Scenario. If the Level I Methodology is a valid tool, the different Scenarios would result in different case studies being selected as the basis for pattern-matching. Figure 5.8 illustrates that this was indeed the case. In addition, it would also be expected that each Scenario would generate a cluster of case studies selected, indicating agreement among the subjects as to which case studies are applicable to each Scenario. While there was less than perfect agreement, Figure 5.8 does indicate substantial agreement among the subjects. This agreement also lends support to the statement that the Level I Checklist is also a reliable method for assessing ergonomic problems. Finally, the assessment, if valid, would also be expected to generate different scores for the five Body Region Priority Scores, for each Scenario. Figure 5.9 illustrates that this was the case, lending additional support for the conclusion that the Level I Checklist is a valid method for assessing ergonomic problems.

Figure 5.7
Beta Test vs. Gold Standard

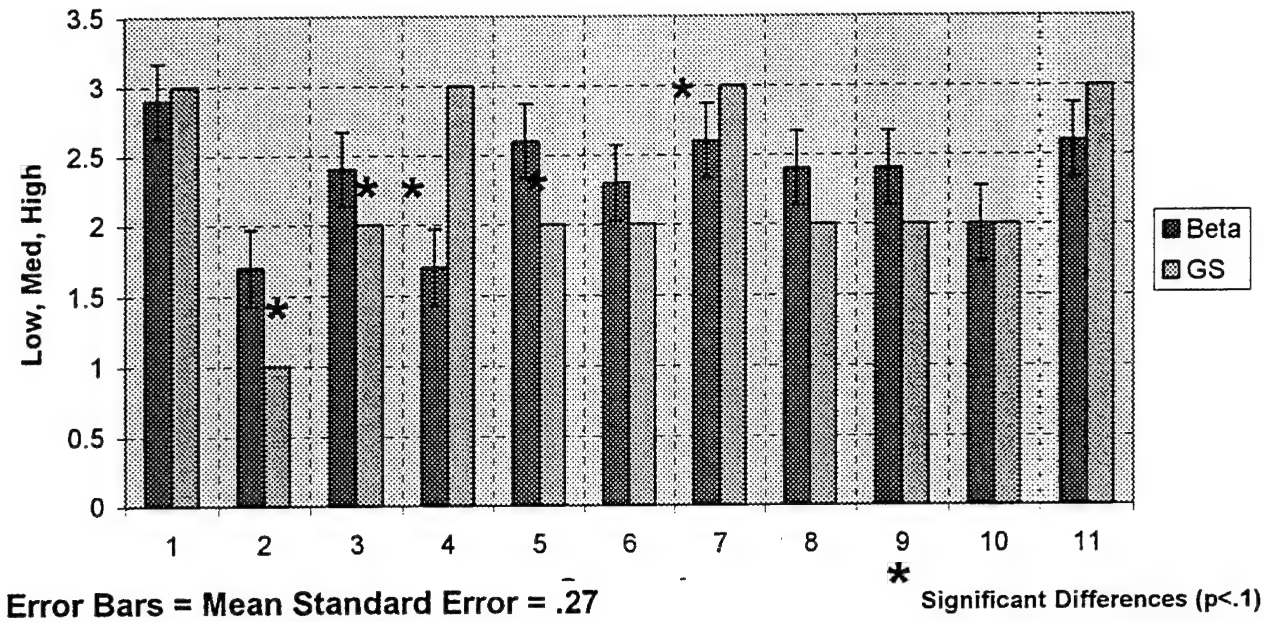


Figure 5.8
Beta Test Case Study Agreement

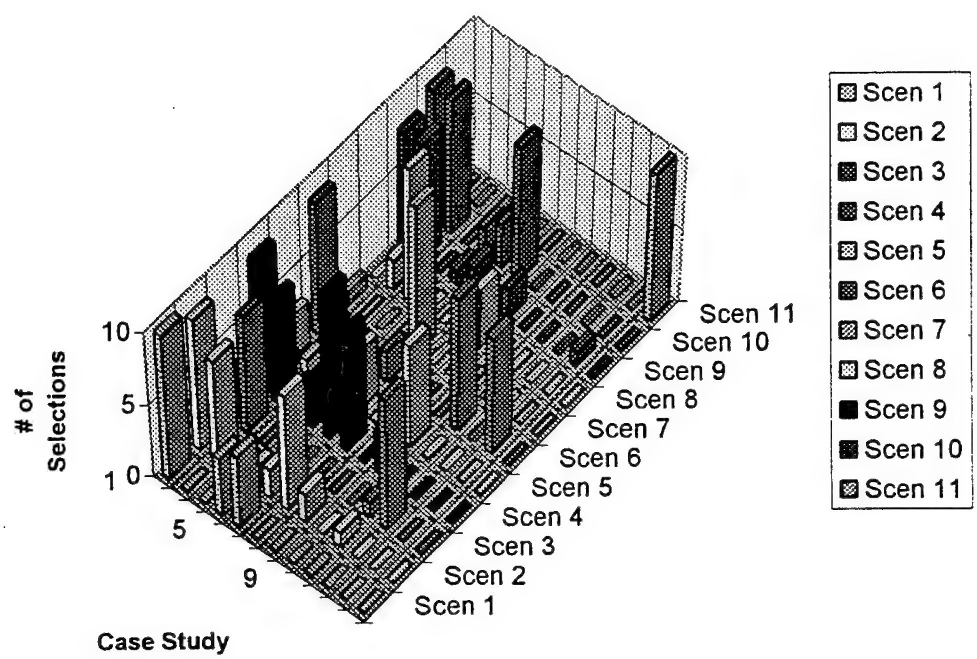
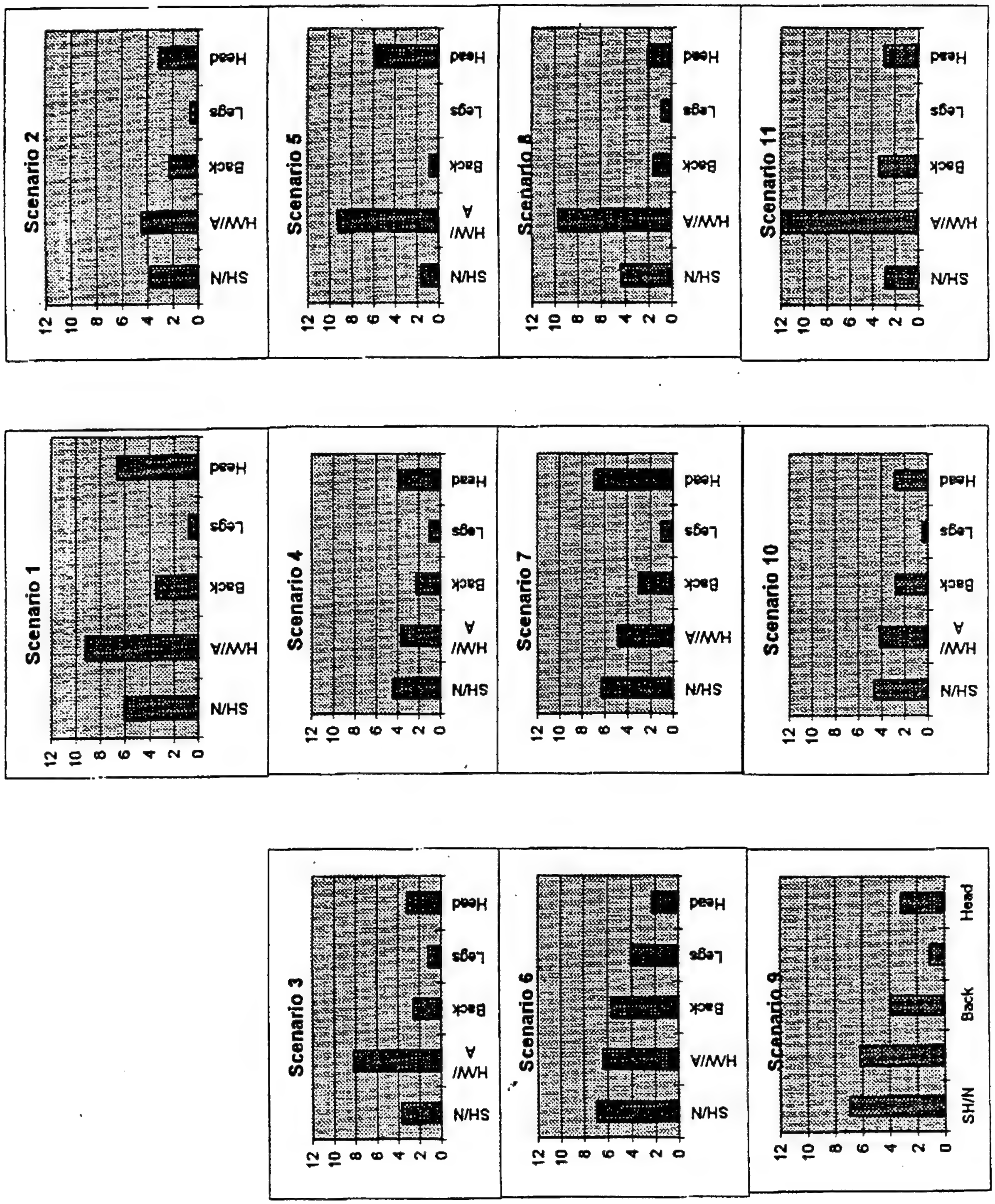


Figure 5.9
Rating Pattern for Each Scenario by Body Part - Average Rating
Beta Test



5.3.3 Predictive Validity. As anticipated, the power was insufficient to establish predictive validity for the administrative areas. No relationships were statistically significant, although two moderately strong correlations were found; hands/wrists/arms ($R=.40$) and legs/knees/feet ($R=.37$). These initial positive results suggest that larger scale predictive validity assessments should be considered based on the strength of relationship present in this preliminary study.

5.4 PRACTICALITY

The most significant aspect of the entire process is the effectiveness of the Guide in enabling the users to select the appropriate corrective actions. The measure of practicality used in testing focused on whether the Methodology could be applied and completed within the time guidelines established by the Air Force.

5.4.1 Usability

5.4.1.1 Results from Alpha Testing. A focus group session was conducted to obtain usability comments from the ergonomists who participated in the alpha test. The changes that were suggested for each of the Methodology components (e.g., User Instructions, Job Scenarios, Level I Checklist, and Case Study Problem-Solving Matrices) were incorporated into the materials prepared for the Beta Test. The specific changes and rationale are provided in Appendix B.

5.4.1.2 Results from Beta Testing. Information on usability was obtained from technicians from the ergonomist who administered the beta test. The ergonomist obtained comments throughout the testing and conducted a focus group/out-briefing with participants to obtain additional comments after the testing was complete.

The ergonomist encouraged the technicians to ask clarification questions during the testing, as needed, but were made aware that the ergonomist would provide responses limited to information contained within the existing materials. In fact, most of the technicians asked questions whose answers were already contained in the Job Scenario or in the Instructions. For clarification, the ergonomist simply referred the technician to that information. The process for responding to each questions was:

- restated the question;
- directed the technician back to the Instructions and/or Job Scenario; and
- assisted the technician in responding to the original question in light of the new information

The questions that the technicians asked as they learned and applied the Methodology during the testing were recorded. The content of the questions provided information on usability. The questions, responses, and impact on the Methodology design are provided in Table 5.7.

Table 5.7
Technician Questions and Experimenter Responses:
Lessons Learned During the Beta Test

Question	Response
Question 1. Do I mark all of the tasks/times from the Job Scenario (Specific Tasks & Times section) in the Work Content Matrix on Ergonomics Checklist page 1.	**Response:** Yes, according to the instructions. **Interpretation:** This question is specific to the mechanics of transferring information from the Job Scenario to the Work Content Matrix. In actual use, the technician will ask the employee to provide the work frequency range by asking for a range for each of the task types **Impact on the Final Methodology**: In the final User's Guide, provide instructions for how to approach and interview the employee in order to obtain the appropriate information
Question 2. What is the definition of a Monitoring task? Is pressing the buttons part of the task? What about the "computer use/keying" section?	**Response:** Ergonomist: Is the pressing of buttons part of the monitoring task? Technician: yes. Ergonomist: Then, it is part of the monitoring task. Ergonomist: Is use of the keyboard part of the monitoring task? Technician: no. **Ergonomist:** Then, it is not part of the monitoring task. **Interpretation:** There is insufficient definition for the Monitoring Task. **Impact on the Methodology**: Change the Monitoring task type into Monitoring Visual Displays (Vigilance) in the Case Study Problem-Solving matrix.

Table 5.7
Technician Questions and Experimenter Responses:
Lessons Learned During the Beta Test (Cont'd)

Question	Response
Question 3. How do you tell how much 15 degrees is (Shoulder/Neck Qs 1 and 2)?	**Response:** The ergonomist provided a physical demo of shoulder position at 90 degrees and at 45 degrees as major landmarks. Instructor also provided a sketch showing a person in a seated position with a 15 degree and 45 degree angle. The sketch was shown to the entire group of Beta Testers. **Interpretation:** Lack of a visual definition for the 15 degree body position could introduce variability in Job Factor interpretation. **Impact on Methodology:** Provide a Glossary for these (and all other) questions which provides a more detailed description of the Job Factor and the intent of the question. Also provide the technician with hints on "what to look for" when using the Level I Checklist.
Question 4. What if the employee **perceives** (during an actual field analysis) that the light levels are inadequate - what should you write?	**Response:** Since light level perception is reality to many employees, and if the employee provides this comment, make note of it. When implementing the use of the final Methodologies, information on light levels should be obtained from previous measures taken by BEF. **Interpretation:** The employee will not be asked to rate light levels during field use of the Methodology. The technician will obtain this information (already on file for the shop) prior to conducting the Level I Checklist. **Impact on Methodology:** No change is suggested.

Table 5.7
Technician Questions and Experimenter Responses:
Lessons Learned During the Beta Test (Cont'd)

Question	Response
Question 5. I already answered the questions for the legs/feet when I did the "computer use" part of the job. Do I need to answer the same questions for the "calling/telephone use" part of the job (and the two other additional tasks)?	**Response:** Ergonomist: Are the legs/feet exposed to the same Job Factor when "calling" as well as when doing "computer use?" Technician: yes. Ergonomist: Then mark the checklist accordingly. **Interpretation:** Lack of experience in assessing exposure to ergonomics risk factors may be the source for this type of question. **Impact on the Methodology**: No changes will be made to the Methodology. However, the topic will be included in training provided to technicians in order to prepare them to apply the Methodology.
Question 6. One of the parts has a high rating. Two of the body parts have a "tie" medium rating. Which of the "mediums" do I use?	**Response:** Include all three body areas when you review the case studies and identify relevant controls. **Interpretation:** This question is specific to the Beta Test. In order to keep the statistical analysis of results as efficient as possible, the instructions were designed to focus the technician's problem-solving efforts to the two highest rated tasks and the two highest rated body regions within those tasks.

Comments provided by the technicians were favorable. Each of the technicians thought that the process was understandable and easy to use. They also thought that the method could be used to pin-point specific workstation concerns and measure the impact of changes. The positive feedback is listed below:

- glossary is not necessary since most of the risk factor questions are (worded to be) as simple as possible;
- provides a quick way of identifying basic improvement strategies;
- easy enough to have a shop supervisor do it;
- will help us determine if an employee complaint is consistent with what we see (objectively) in the work; and
- continue to present solutions in the categories of "modifications/adjustments" and "purchases/major changes" - too much variation in what Air Force installations/shops consider short-term/inexpensive and long-term. In addition,

attaching a numerical estimate on "high", "medium", and "low" cost may not be helpful since judgments on these may vary greatly from shop to shop/base to base.

The technicians provided suggestions for improvement. They were:

- computerize the process;
- train the shop supervisors to use the Methodology;
- provide a way to help us estimate body angles (e.g., question 1)
- instructions should say that you need to complete the process on 2-3 jobs before getting comfortable (and fast) with the process;
- should show "neutral" positions along with non-neutral positions in checklist question illustrations; and
- consider combining the "keying/typing," and "mousing" case studies into a generic "computer use" case study - will save time in identifying controls.

Each of the suggestions, with exception to computerizing the process, was incorporated into the final Guide. Computerizing the Guide was not a prioritized work effort of HQ AFMC/SGC. A Glossary has been created to educate and instruct the technicians on "what to look for" and how to make judgments about Job Factor exposure. The Glossary is included in Appendix 2 of the Guide. The typing/keying and mousing Case Studies have been combined into a "Use of Computer/General Word Processing" Case Study. This decision was approved by AL/OEMO since the problem-solving process will be made more efficient.

A decision about how the shop supervisor might become involved in the applying the Methodology, must be determined by the Air Force.

5.4.2 Time Requirements. The time requirements for completing the analysis and for identifying and selecting control measures were calculated based on the beta test sessions. The mean time for completing the Level I Checklist and scoring process was 20.6 minutes with a standard deviation of 11.5 minutes. The mean time for identifying and selecting control measures was 17.8 minutes with a standard deviation of 8.3 minutes. These values are well within the criteria established, indicating that this Methodology can be used quickly.

5.4.3 Selection of Corrective Actions.

5.4.3.1 Beta Test vs. Consensus Scores: Corrective Action Reliability. The data indicate clearly that the technicians were extremely reliable in selecting corrective actions.

Each beta test Scenario was analyzed individually to determine the reliability with which the subjects selected the various corrective actions. Intraclass correlation coefficients [39] were calculated and tested for each Scenario. Table 5.8 shows the ICC and the Chi^2 value for each Scenario. The probability associated with each ICC was less than 0.000001. This means that there is less than 1 chance in 1,000,000 that these results were found due to chance alone. The reasonable interpretation is that this procedure allows the novice user to be extremely reliable in selecting corrective actions to address/reduce exposure to ergonomics risk factors.

Table 5.8
Corrective Action Reliability:
Agreement Among Beta Test Subjects for Selecting Corrective Actions

Scenario	ICC	CHI^2
1	0.36	490.1
2	0.24	362.6
3	0.44	566.9
4	0.15	273.6
5	0.28	401.8
6	0.23	354.2
7	0.33	459.3
8	0.90	1044.0
9	0.13	249.1
10	0.14	259.5
11	0.814	957.7

5.4.3.2 Corrective Action Validity. The results indicate that the technicians agreed extremely well with the ergonomists. The percentage agreements ranged from 63% to 77%, which indicates a very high level of agreement, as would be expected given the ICC results.

A consensus corrective action list was generated from the alpha test data and the Gold Standard data. Beta test data was scored for correctness using this consensus list as a template. Intraclass correlation coefficients and percentage agreements were calculated from this scoring. Table 5.9 presents the ICCs and Chi^2 statistics. All of the probabilities were less than 0.000001. Again, this indicates that there is less than a 1 in 1,000,000 chance that these results were due to chance. It is much more likely that the process

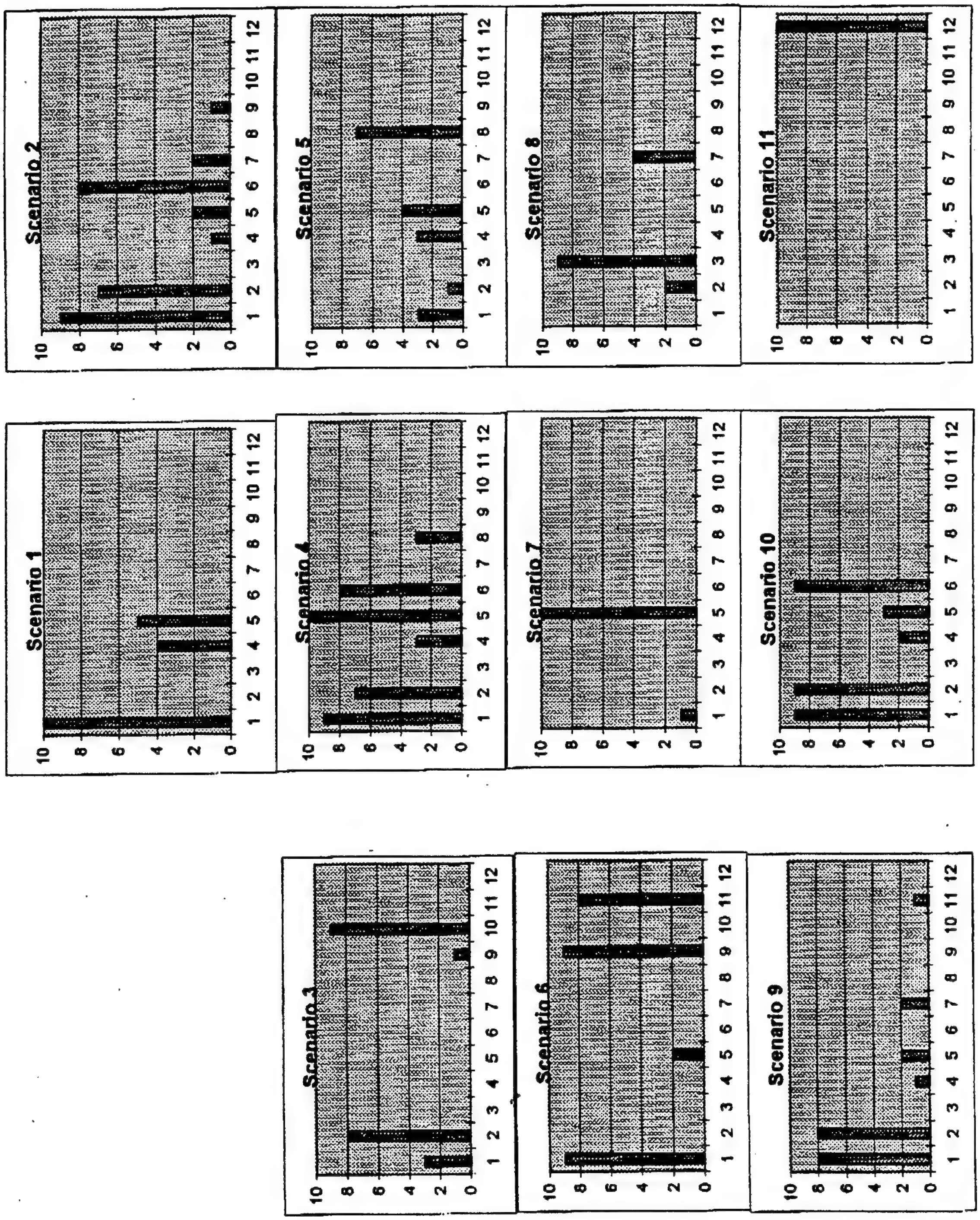
actually allows the novice subjects to generate ergonomic corrective actions that agree with the experts.

Table 5.9
Corrective Action Validity: Agreement Between Beta Test Subjects and Ergonomists for Selecting Corrective Actions

Scenario	Percentage Agreement	ICC	CHI^2
1	64.08	.45	579.5
2	65.65	.31	433.8
3	73.13	.31	430.9
4	64.43	.40	524.7
5	65.91	.40	531.3
6	65.56	.36	488.3
7	70.60	.37	497.6
8	77.04	.32	444.4
9	67.39	.33	457.0
10	63.13	.37	501.3
11	68.08	.50	634.1

The results indicate that the technicians agreed substantially with the ergonomists, and that the agreement was reliable within a Scenario and for all Scenarios. This strongly suggests that the process actually provides the desired answers.

Figure 5.10
Case Study Agreement
Number of Subjects Selecting Each of 12 Case Studies
Beta Test



5.5 CONCLUSIONS

The validation process has assessed the reliability, sensitivity, validity, and practicality of the Level I Ergonomics Assessment and Problem-Solving Methodology for Administrative Work Areas in several ways. While there are some issues that were identified for improvement in subsequent Methodology development efforts (e.g., Maintenance/Inspection), the Methodology should be considered to have performed adequately. The specific detail summary is provided below.

For inter-rater reliability:

- Agreement rates between end users were similar to that which has been reported in the literature.

- For Overall Job Priority score, the process demonstrated marginally significant reliability. In addition, there were no significant differences in the overall Job Priority scores between the ergonomists and technicians. This supports the opinion that the technicians obtain similar priority scores as experts.

- Across all questions in the Level I Checklist, the Job Factors selected by technicians agreed with ergonomists 67% percent of the time. This means that technicians can recognize the same risk factors as ergonomists.

For sensitivity:

- The Level I Checklist significantly and accurately distinguished between Job Scenarios that were judged by the Gold Standard Ergonomists to be of High or Medium priority for intervention.

- There was a significant relationship between the assessment results of technicians and the Gold Standard ergonomists. This means that technicians are expected to be able to effectively identify High and Medium priority administrative jobs.

For content validity:

- All of Job Factor questions are supported by scientific research. The list of Job Factor questions was comprehensive in covering ergonomic risk factors which are expected to occur in an administrative environment. The overall theoretical structure of the Level I Checklist is a commonly used structure which has been used in other validated methods.

For predictive validity:

- As suspected, moderately strong but insignificant correlations were found between discomfort data and Body Region Priority Scores. These results suggest that a large scale predictive validity assessment should be considered to measure the predictive validity of this ergonomics assessment method.

For concurrent validity:

- The Level I Methodology identified different Case Studies (as the initial basis for pattern-matching) for different jobs. Testing also revealed that there was substantial agreement between technicians and the Gold Standard ergonomists for 91% of the Job Scenarios. This means that the Methodology enabled technicians to identify the *appropriate* case studies as the basis for effective control identification. This is the feature of the Methodology design that enables technicians to select appropriate corrective actions for the majority of administrative jobs.

For usability/practicality:

- The Methodology was easy to use and can be completed in well under the time targets established by the Air Force. Usability comments provided by technicians were favorable. Suggestions, which were limited to ideas for eliminating redundancy, have been incorporated into the final Methodology.

- Technicians consistently agreed in selecting corrective actions. This means that technicians can be expected to make the same type of recommendations to shop supervisors.

- The solutions selected by the technicians agreed with the solutions selected by a consensus of ergonomists 63% to 77% of the time. This result suggested that the Methodology assists technicians in generating solutions that experts would recommend. This was one of the primary objectives of the Methodology.

Opportunities for Improvement

- The response rates for many questions in the assessment were below desired levels. This can be explained by the limited number of jobs evaluated (11 jobs) and the wide variety of Job Factors which can occur in administrative tasks. The Methodology designers made the decision to provide a more comprehensive assessment tool even if some of the questions would not be applicable in all cases. Nevertheless, the scientific literature and professional

opinion indicated that all of the Job Factors included are important for administrative tasks.

- The overall level of agreement for specific questions selected for a particular job was lower than the desired criteria. *However, the rates were comparable to agreement rates obtained in published validations for other ergonomics assessment methods.* In addition, regardless of the agreement on individual questions, this study provided evidence to indicate that the Methodology assists technicians in arriving at the similar solutions as would be selected by an ergonomist.

- Several questions exhibited agreement which was lower than the average. An effort will be made to avoid these types of questions in subsequent Methodology development efforts (e.g., Maintenance and Inspection).

- Tasks with one extreme Job Factor tended to be scored lower than tasks with several moderate Job Factors. Future assessment development efforts will seek to address this issue through the design of the tool.

In summary, the primary strengths of the Guide are:

- it is easy to use;

- it has shown good acceptance by the most likely end user population (BEF technicians);

- it meets and improves on the "time for completion" requirements established by the Air Force; and

- it enables junior level Air Force personnel to identify appropriate corrective actions to the ergonomics risk factors identified in administrative jobs in a way that provides answers that are consistent to that which an ergonomist would provide, all in a time-effective manner.

The Level I Ergonomics Assessment and Problem-Solving Methodology for Administrative Work Areas can be considered an effective means for identifying and controlling ergonomics hazards in administrative work areas. In addition, it represents a strong foundation for developing similar approaches to reducing or eliminating the potential for WMDs in Maintenance/Inspection, Warehouse, and Assembly Work Areas.

6.0 REFERENCES

1. U. S. Department of Labor, Occupational Safety and Health Administration, (1995) *Draft Ergonomics Protection Standard.* Washington, D. C.

2. American National Standards Institute (ANSI) National Safety Council Draft Standard Z-365, (1992, June 11). *Control of Cumulative Trauma Disorders.* Draft Outline.

   Appendix 23-A. (1992. November 2). *Checklist for Evaluation of Ergonomic Stress in Industrial Shops.*

   Appendix 23-B. *Checklist for Evaluation of Ergonomic Stress at Workstations Equipped with Video Display Terminals.*

   Appendix A. (1993, June 4). *Sample Surveillance Tools.*

   Appendix B. *Controlling Workplace Risk Factors.*

3. Kemmlert, K. (1994). A Method Assigned for the Identification of Ergonomic Hazards - PLIBEL. *Scandinavian Journal of Rehabilitation Medicine* (Vol. 26, pp. 1-21).

4. The Joyce Institute, (1990). Job Evaluation Checklist. *Practical Office Ergonomics.*

5. The Joyce Institute, (1995). Uniroyal Industrial and Office Ergonomics Checklists. Unpublished.

6. Lifshitz, Y., and Armstrong, T. (1986). A Design Checklist for Control and Prediction of Cumulative Trauma Disorder in Intensive Manual Jobs. In *Proceedings of the Human Factors Society 30th Annual Meeting.* (pp. 945-950).

7. McAtammey, L., and Corlett, E.N. (1993). RULA - A Survey Method for the Investigation of Work Related Upper Limb Disorders. *Applied Ergonomics* (Vol. 24, No. 2, pp. 91-99).

8. Keyserling, W.M., Stetson, D.S., Silverstein, B.A., and Brouwer, M.L. (1993) A Checklist for Evaluation Ergonomic Risk Factors Associated with Upper Extremity Cumulative Trauma Disorders. *Ergonomics* (Vol. 36, No. 7, pp. 807-831).

9. Stetson, D.S., Keyserling, W.M., Silverstein, B.A., and Leonard, J.A. (1991, November). Observational Analysis of the Hand and Wrist: A Pilot Study, *Applied Occupational and Environmental Hygiene* (Vol. 6, No. 11, pp. 937).

10. U.S. Department of Labor. (1991) *Dictionary of Occupational Titles.* Washington, D. C.

11. American National Standards Institute (ANSI)/Human Factors Society Standard 100 (1988). *Human Factors Engineering of Visual Display Terminal Workstation.*

12. Chaffin, D.B., and Andersson, G.B.J. (1984). *Occupational Biomechanics* (pp. 304). New York: John Wiley & Sons.

13. Putz-Anderson, V. (1992). *Cumulative Trauma Disorders: A Manual for Musculoskeletal Diseases of the Upper Limb.* London, England: Taylor & Francis.

14. Snook, S. H., Ciriello, V.M. (1991). "The Design of Manual Handling Tasks: Revised Tables of Maximum Acceptable Weights and Forces". *Ergonomics* (Vol. 34, No. 9.).

15. Chaffin, D.B. (1973). Localized Muscle Fatigue: Definition and Measurement. *Journal of Occupational Medicine* (Vol. 15, pp. 346-354).

16. Dale, W.A. (1982). Thoracic Outlet Compression Syndrome. *Archives of Surgery* (Vol. 117, pp. 1437-1445).

17. Tyson, R.R., and Kaplan, G.F. (1975). Modern Concepts of Diagnosis and Treatment of the Thoracic Outlet Syndrome. *Orthopaedics Clinics of North America* (Vol. 6, pp. 507-519).

18. Nachemson, A. and Elfstrom, G. (1970) Intravital Dynamic Pressure Measurements in Lumbar Discs. *Scandinavian Journal of Rehabilitation Medicine - Supplement I.*

19. Van Wely, P. (1970). Design and Disease. *Applied Ergonomics* (Vol. 1, No. 5, pp. 262-269).

20. Fard, H., and Mital, A. (1993). A Psychophysical Study of High and Very High Frequency Manual Materials Handling - Part I: Lifting and Lowering. *International Journal of Industrial Ergonomics* (Vol. 12, pp. 127-141, 143-156).

21. Kumar, S. (1995). Development of Predictive Equations for Lifting Strength. *Applied Ergonomics* (Vol. 26, No. 5, pp. 327-341).

22. Waters, T., V. Putz-Anderson., A.Garg,. (1994). *Applications Manual for the Revised NIOSH Lifting Equation.* U.S. Department of Health & Human Services, Centers for Disease Control, Cincinnati, Ohio.

23. Konz, S. (1994). Standing. *Ergonomics* (Vol. 37, No. 4, pp. 677).

24. Ryan, G.A. (1989). Musculoskeletal Symptoms in Supermarket Workers. *Ergonomics* (Vol. 32, No. 4, pp. 359-371).

25. Bergqvist, M.G., Almby, B., Jansson, E.S. (1994). Hand and Shoulder Ailments Among Laboratory Technicians Using Modern Plunger-Operated Pipettes. *Applied Ergonomics* (Vol. 25, No. 2, pp. 88).

26. Keyserling, W.M., Brouwer, M., and Silverstein, B.A. (1993). The Effectiveness of a Joint Labor-Management Program in Controlling Awkward Postures of the Trunk, Neck and Shoulders: Results from a Field Study. *International Journal of Industrial Ergonomics* (Vol. 11, pp. 51-65).

27. Canadian Standards Association (1989). *Office Ergonomics: A National Standard of Canada* (pp. 56). (CAN/CSA-Z412-M89). Canadian Standards Association, Rexdale, Ontario.

28. Silverstein, B.A., Fine, L.J., and Armstrong, T.J. (1986). Hand Wrist Cumulative Trauma Disorders in Industry. *British Journal of Industrial Medicine* (Vol. 43, pp. 779-782).

29. Silverstein. B.A., Fine, L.J., and Armstrong, T.J. (1987). Occupational Factors and Carpal Tunnel Syndrome. *American Journal of Industrial Medicine* (Vol. 11, pp. 343-358).

30. Reynolds, J.L., Drury, C.G., and Broaderick, R.L. (1994). A Field Methodology for the Control of Musculoskeletal Injuries. *Applied Ergonomics.* (Vol. 25, No. 1, pp. 3-16).

31. OSHA Draft Ergonomic Protection Standard (listed as a risk factor in OSHA's Workplace Risk Factor Checklist).

32. Kuorinka, I., and Koshinen, P. (1979). Occupational Rheumatic Diseases and Upper Limb Strain in Manual Jobs in a Light Mechanical Industry. *Scandinavian Journal of Work, Environment & Health* (Vol. 5, No. 3, pp. 39-47).

33. ASHRAE Standard 62.

34. Meister, D. (1985). *Behavioral Analysis and Research Methods.* New York: John Wiley and Sons.

35. Cohen, J. (1960). A Coefficient of Agreement for Nominal Scales. *Educational and Psychological Measurement* (Vol. 20, pp. 37 - 46).

36. Brennan, R.L. and Prediger, D.J. (1981). Coefficient Kappa: Some Uses, Misuses and Alternatives. Educational and Psychological Measurement. (Vol. 41 pp. 687-699).

37. Landis, R. and Koch, G. (1977) The Measurement of Observer Agreement for Categorical Data. *Biometrics* (Vol. 33, pp. 159-174).

38. Tatsuoka, M.M., (1974). Number 3: Classification Procedures: Profile Similarity in Selected Topics in Advanced Statistics: An Elementary Approach. Champaign, Illinois: Institute for Personality and Ability Testing.

39. Bartko, J. J. and Carpenter, W. T. (1976). On the Methods and Theory of Reliability. *The Journal of Nervous and Mental Disease* (Vol. 163, No. 5, pp. 307-317).

7.0 BIBLIOGRAPHY

Abu-Ali, M., Purswell, J.L., and Schlegel, R.E. (1994, September). Psychophysically Determined Work-Cycle Parameters for Repetitive Hand Gripping. *International Journal of Industrial Ergonomics.*

Adams, M., Franklin, G., and Barnhart, S. (1994). Outcome of Carpal Tunnel Surgery in Washington State Workers' Compensation. *American Journal of Industrial Medicine* (Vol. 25, pp. 527-536).

AFI 48-101. Aerospace Medical Operations.

AFI 91-301. Air Force Occupational & Environmental.

AFOSH STD 127-31. Personal Protective Equipment.

AFOSH STD 161-17. Standardized Occupational Health Program.

AFOSH STD 48-1. Respiratory Protection Program.

AFOSH STD 48-17. Integrated Occupational Health Program.

AFOSH STD 48-3 (Draft). Ergonomics Program.

AFOSH STD 91-204. Investigating & Reporting US Air Force Mishaps.

Aghazadeh, F., Bisesi, M.S., Rivas, R.D. (1995). Comfort of Personal Protective Equipment. *Applied Ergonomics,*(Vol. 26, No. 3, pp. 195-198).

American National Standards Institute (ANSI) Draft Standard Z-365, (June 1993). *Control of Trauma Disorders* (pp. 6-4).

American National Standards Institute (ANSI) National Safety Council Draft Standard Z-365, (1995, April 17). *Control of Work Related Cumulative Trauma Disorders.* Working draft.

American National Standards Institute (ANSI) National Safety Council Draft Standard Z-365, (1992, June 11). *Control of Cumulative Trauma Disorders.* Draft Outline.

American National Standards Institute (ANSI)/Human Factors Society Standard 100, (1988). *Human Factors Engineering of Visual Display Terminal Workstations.* (p.11).

American National Standards Institute (ANSI)/Human Factors Society Standard 100, (1988). *Human Factors Engineering of Visual Display Terminal Workstations* (pp. 17-31).

American National Standards Institute (ANSI)/Human Factors Society Standard 100, (1988). *Human Factors Engineering of Visual Display Terminal Workstations* (pp. 14).

American National Standards Institute (ANSI)/Human Factors Society Standard 100 (1988). *Human Factors Engineering of Visual Display Terminal Workstation.*

Appendix 23-A. (1992. November 2). *Checklist for Evaluation of Ergonomic Stress in Industrial Shops.*

Appendix 23-B. *Checklist for Evaluation of Ergonomic Stress at Workstations Equipped with Video Display Terminals.*

Appendix A. (1993, June 4). *Sample Surveillance Tools.*

Appendix B. *Controlling Workplace Risk Factors.*

Application of Survival Analysis to CTD Risk Assessment. (1992). In *Proceedings of the Human Factors Society 36th Annual Meeting.*

Armstrong, T., Werner, R., Waring, W., and Foulke, J. (1986). *Intra-Carpal Canal Pressure in Selected Hand Tasks.* The University of Michigan.

Bartko, J. J. and Carpenter, W. T. (1976). On the Methods and Theory of Reliability. *The Journal of Nervous and Mental Disease* (Vol. 163, No. 5, pp. 307-317).

Bateman, J.E. (1983). Neurologic Painful Conditions Affecting the Shoulder. *Clinical Orthopaedics and Related Research* (Vol. 173, pp. 44-54).

Batra, S., Wang, M.J., and Bishu, R.R. (1994). Glove attributes: Can They Predict Performance? *International Journal of Industrial Ergonomics* (Vol. 14, pp. 201-209).

Bergqvist, M.G., Almby, B., Jansson, E.S. (1994). Hand and Shoulder Ailments Among Laboratory Technicians Using Modern Plunger-Operated Pipettes. *Applied Ergonomics* (Vol. 25, No. 2, pp. 88)

Bergqvist, U. (1995). Video Display Terminal Work - A Perspective on Long Term Changes. *International Journal of Industrial Ergonomics.* (Vol. 16, pp. 201-209).

Bigos, S., Battie, M., Spengler, D., Fisher, L., Fordyce, W., Hansson, T., Nachemson, A., and Wortley, M. (1991). A Prospective Study of Work Perceptions and Psychosocial Factors Affecting the Report of Back Injury. *Spine* (Vol. 16, No. 1, pp. 1-6).

Bishu, R.R., and Klute, G. (1995). The Effects of External Vehicular Activity (EVA) Gloves on Human Performance. *International Journal of Industrial Ergonomics* (Vol. 16, pp. 165-174).

Bjelle, A., Hagberg, M. and Michaelsson, G. (1979). Clinical and Ergonomic Factors in Prolonged Shoulder Pain Among Industrial Workers. *Scandinavian Journal of Work, Environment & Health* (Vol. 5, pp. 205-210).

Bond, G.G., Bodner, K.M., Sobel, W. Shellenberger, R.J. and Flores, G.H. (1988). Validation of Work Histories Obtained from Interviews. *American Journal of Epidemiology* (Vol. 128, No. 2, pp. 343-351).

Borg, G. (1970). Perceived Exertion as an Indicator of Somatic Stress. *Scandinavian Journal of Rehabilitation Medicine* (Vol. 2, pp. 92-98).

Buckle, P. (1994). Measurement of Exposure Variables in Research Relating to Musculoskeletal Disorders, with Specific Reference to Work with Display Units. University of Surrey.

Burdorf, A. (1992). Exposure Assessment of Risk Factors for Disorders of the Back in Occupational Epidemiology. *Scandinavian Journal of Work, Environment & Health* (Vol. 18, pp. 1-9).

Cakir, A., Hart, D.J., and Stewart, T.F.M. *Visual Display Terminals: A Manual Covering Ergonomics Workplace Design, Health and Safety, Task Organization*. Chichester: John Wiley & Sons.

Canadian Standards Association (1989). *Office Ergonomics: A National Standard of Canada* (pp. 56). (CAN/CSA-Z412-M89). Canadian Standards Association., Rexdale, Ontario.

Carayon, P., and Smith, M. Work Organization Factors and Upper Limb Musculoskeletal Disorders in Offices. University of Wisconsin, Madison.

Carrasco, C., Coleman, N., and Healey, S. (1995). Packaging Products for Customers: An Ergonomics Evaluation of Three Supermarket Checkouts. *Applied Ergonomics* (Vol. 26, No. 2, pp. 101).

Chaffin, D. B., Park, K. S. (1973). " A Longitudinal Study of Low-Back Pain as Associated with Occupational Weight Lifting Factors". *American Industrial Hygiene Association Journal*, pp. 513-525.

Chaffin, D.B. (1973). Localized Muscle Fatigue: Definition and Measurement. *Journal of Occupational Medicine* (Vol. 15, pp. 346-354).

Chaffin, D.B., and Andersson, G.B.J. (1984). *Occupational Biomechanics* (pp. 304). New York: John Wiley & Sons.

Cheadle, A., Franklin, G., Wolfhagen, C., Savarino, J., Liu, P., Salley, C., and Weaver, M. (1994, February). Factors Influencing the Duration of Work-Related Disability: A Population-Based Study of Washington State Workers' Compensation. *American Journal of Public Health* (Vol. 84, No. 2).

Cohen, J. (1960). A Coefficient of Agreement for Nominal Scales. *Educational and Psychological Measurement* (Vol. 20, pp. 37 - 46).

Cole, L and Rosa, R. (1994). Construction and Validation of a Musculoskeletal Risk Questionnaire . In *Proceedings of the Human Factors and Ergonomics Society 38th Annual* (pp. 984).

Cole, L. L. (1995, November 20). *Construction and Validation of a Musculoskeletal Risk Questionnaire.* Dissertation.

Colombini, D., Occhipinti, E., Molteni, G., Semeraro, D., and Grieco, A. (1992, September). A Study of Muscle Activity in Workplaces with Keyboard Operations. *Abstract Book from Third International Scientific Conference on Work with Display Units.*

Corlett, E.N. (1983). Analysis and Evaluation of Working Postures. In T.O. Kvalseth (Ed.). *Ergonomics of Workstation Design* (pp. 12-15). London: Butterworths.

Council of the European Communities (1990, May). Council Directive 90/270/EEC of Article 16 (1) of Council Directive 89/391/EEC..

Dale, W.A. (1982). Thoracic Outlet Compression Syndrome. *Archives of Surgery* (Vol. 117, pp. 1437-1445).

Delisie, A., Gagnon, M. (1995, July). Segmental Dynamic Analysis When Throwing Loads. *International Journal of Industrial Ergonomics* (Vol. 16, No. 1, pp. 9-21).

Dempsey, P.G., and Ayoub, M.M. (1996). The Influence of Gender, Grasp Type, Pinch Width and Wrist Position on Sustained Pinch Strength. *International Journal of Industrial Ergonomics* (Vol. 17, pp. 259-273).

Dickinson, C.E., Campion, K., Foster, A.F., Newman, S.J., O'Rourke, A.M.T., and Thomas, P.G. (1992, June). Questionnaire Development: An Examination of the Nordic Musculoskeletal Questionnaire. *Applied Ergonomics* (Vol. 23, No. 3, pp. 197-201).

Drury, C.G. (1990). Methods for Direct Observation of Performance, in Wilson, J.R., Corlett, and E.N., (eds.). *Evaluation of Human Work (* pp. 35-57). London: Taylor and Francis.

Dunbar, E. (1993). The Role of Psychological Stress and Prior Experience in the Use of Personal Protective Equipment. *Journal of Safety Research* (Vol. 24, No. 3, pp. 181-187).

Engkvist, I, Hagberg, M., Wigaeus-Hjelm, E., Menckel, E., Ekenvall, L., and PROSA Study Group. (1995) Interview Protocols and Ergonomics Checklist for Analyzing (sic) Overexertion Back Accidents Among Nursing Personnel. *Applied Ergonomics.* (Vol. 26, no 3, pp. 213-220).

Fard, H., and Mital, A. (1993). A Psychophysical Study of High and Very High Frequency Manual Materials Handling - Part I: Lifting and Lowering. *International Journal of Industrial Ergonomics* (Vol. 12, pp. 127-141).

Fard, H., and Mital, A. (1993). A Psychophysical Study of High and Very High Frequency Manual Materials Handling - Part II: Carrying and Turning. *International Journal of Industrial Ergonomics* (Vol. 12, pp. 143-156).

Feldman, R.G., Goldman, R., and Keyserling, W.M. (1983). Peripheral Nerve Entrapment Syndromes and Ergonomic Factors. *American Journal of Industrial Medicine* (Vol. 4, pp. 661-681).

Fleiss, J. L. and Cohen, J., The Equivalence of Weighted Kappa and the Intraclass Correlation Coefficient as Measures of Reliability. *Educational and Psychological Measurement* (Vol. 33, pp. 613 to 619).

Garg, A., and Moore, J.S. (1993). A Job Analysis Method for Predicting Risk of Upper Extremity Disorders at work: Preliminary Results, in R. Nielsen and K. Jorgensen, (eds.). *Advances in Industrial Ergonomics and Safety* (pp. 163-169). Taylor and Francis.

Garg, A., Owen, B. (1994). Prevention of Back Injuries in Health Care Workers. *International Journal of Industrial Ergonomics (*Vol. 14, pp. 315-331).

Graf, M., Guggenbuhl U., Krueger, H., (1995). "An Assessment of Seated Activity and Postures at Five Workplaces". *International Journal of Industrial Ergonomics.* (Vol. 15 pp. 81-90).

Grandjean, E. *Fitting the Task to the Man: A Textbook of Occupational Ergonomics.* (4th Edition, Chapter 1). Taylor & Francis, Ltd.

Grandjean, Etienne, (1988). *Fitting the Task to the Man: A Textbook of Occupational Ergonomics.* Taylor & Francis Ltd., London. pp. 36 - 81.

Grant, K.A., Habes, D.J., and Baron, S.L. (1994). An Ergonomics Evaluation of Cashier Work Activities at Check-Unload Workstations. *Applied Ergonomics* (Vol. 25, No. 5, pp. 310).

Hagberg, M. (1984). Occupational Musculoskeletal Stress and Disorders of the Neck and Shoulder: A Review of Possible Pathophysiology. *International Archives of Occupational and Environmental Health* (Vol. 53, pp. 269-278).

Haigh, R. (1993). The Aging Process: A Challenge for Design. *Applied Ergonomics* (Vol. 24, No. 1, pp. 9).

Hammer, A. W. (1934). "Tenosynovitis", *International Record of Medicine*. (pp. 139-140). Taubman Medical, 610.5 M5 J86 R4.

Harber, P., Bloswick, D., Beck, J., Pena, L., Baker, D., and Lee, J. (1993, August). Supermarket Checker Motions and Cumulative Trauma Risk. *Journal of Occupational Medicine* (Vol. 35, No. 8).

Harber, P., Bloswick, D., Beck, J., Pena, L., Baker, D., and Lee, J. (1992, May). The Ergonomic Challenge of Repetitive Motion with Varying Ergonomic Stresses. *Journal of Occupational Medicine* (Vol. 34, No. 5).

Hedge, A., Powers, J., and Martin, M. (1992, September). Healthy Keyboarding: An Experimental Test of a Negative Keyboard Slope to Minimize Carpal Tunnel Syndrome Risks. *Abstract Book from Third International Scientific Conference on Work with Display Units.*

Herberts, P., Kadefors, R., Hagfors, C. and Sigholm, G., (1984). "Shoulder Pain and Heavy Manual Labor, *Clinical Orthopaedics and Related Research* (pp. 166-178), as cited in Sommerich, C.M., McGlothlin, J. D., Marras., W. S., (1993). "Occupational Risk Factors Associated With Soft Tissue Disorders of the Shoulder: A Review of Recent Investigations in the Literature". *Ergonomics* (Vol. 36, No 6, pp. 697-717).

Heus, R., Daanen, H.A.M., and Haventh, G. (1995). Physiological Criteria for Functioning of Hands in the Cold. *Applied Ergon*omics (Vol. 26, No. 1, pp. 5-13).

Holmer, I. (1994). Cold Stress - Part I: Guide for the Practitioner. *International Journal of Industrial Ergonomics* (Vol. 14, pp. 139-149).

Howarth, Peter Alan, and Instance, Owen (1985). The Association Between Visual Discomfort and the Use of Visual Display Units, *Behavior and Information Technology* (Vol. 4, No. 2, pp. 131-149).

Hubbell, M.P. A Method to Maximize the Effects of Limited Resources to Reduce the Risk of VDT-Related Musculoskeletal Stress at Sites with 1000's of VDT Stations. McDonnell Douglas Aerospace.

Joyce, Marilyn S., and Wallersteiner, U. (1989). *Ergonomics: Humanizing the Automated Office*. South-Western Publishing Co., Cincinnati, OH.

Joyce, Marilyn. (1995). *The Ergonomic Perspective on Psychosocial Issues.* The Joyce Institute, Seattle, WA.

Katz, J., Punnett, L., Simmons, B., Fossel, A., Mooney, N., and Keller, R. (1996, Jan.). Workers' Compensation Recipients with Carpal Tunnel Syndrome. The Validity of Self-Reported Health Measures. *American Journal of Public Health* (Vol. 86, No. 1, pp. 52-56)

Kelly, J. P., Rosenberg, L., Kaufman, D. W. and Shapiro, S. (1990). Reliability of Personal Interview Data in a Hospital-Based Case-Control Study. *American Journal of Epidemiology* . (Vol. 31, No. 1, pp. 79-90).

Kemmlert, K. (1994). A Method Assigned for the Identification of Ergonomic Hazards - PLIBEL. *Scandinavian Journal of Rehabilitation Medicine* (Vol. 26, pp. 1-21).

Kemmlert, K., (1994). A Method Assigned for the Identification of Ergonomic Hazards - PLIBEL. *Scandinavian Journal of Rehabilitation Medicine* (Vol. 26, pp. 1-21).

Keyserling, W.M., (1986) "A Computer-Aided System to Evaluate Postural Stress in the Workplace". *AIHA Journal* (Vol. 47. pp. 641-649)

Keyserling, W.M., Brouwer, M., and Silverstein, B.A. (1993). The Effectiveness of a Joint Labor-Management Program in Controlling Awkward Postures of the Trunk, Neck and Shoulders: Results from a Field Study. *International Journal of Industrial Ergonomics* (Vol. 11, pp. 51-65).

Keyserling, W.M., Stetson, D.S., Silverstein, B.A., and Brouwer, M.L. (1993) A Checklist for Evaluation Ergonomic Risk Factors Associated with Upper Extremity Cumulative Trauma Disorders. *Ergonomics* (Vol. 36, No. 7, P. 810-811).

Keyserling, W.M., Stetson, D.S., Silverstein, B.A., and Brouwer, M.L. (1993) A Checklist for Evaluation Ergonomic Risk Factors Associated with Upper Extremity Cumulative Trauma Disorders. *Ergonomics* (Vol. 36, No. 7, pp. 807-831).

Kihlberg, S. (1995). Biodynamic Response of the Hand-Arm System to Vibration from an Impact Hammer and Grinder. *International Journal of Industrial Ergonomics* (Vol. 16, pp. 1-8).

Kihlberg, S., Kjellberg, A., and Lindbeck, L. (1995). Discomfort from Pneumatic Tool Torque Reaction: Acceptability Limits. *International Journal of Industrial Ergonomics.*

Kilbom, A. (1994). Quantification of Physical Exposure. Institute of Occupational Health, S-17184. *International Journal of Industrial Ergonomics* (Vol. 14, pp. 59-86).

Kilbom, A. (1988). "Intervention Programmes for Work-Related Neck and Upper Limb Disorders: Strategies and Evaluation". *Ergonomics* (Vol. 31, No. 5)

Kilbom, A., Persson. J. and Jonssön, B.G., (1986). "Disorders of the Cervicobrochial Region Among Female Workers in the Electronics Industry. *International Journal of Industrial Ergonomics* (Vol. 1., pp. 37-47).

Kilbom, A., Persson. J., (1988). "Work Technique and its Consequences for Musculoskeletal Disorder". *Ergonomics* (Vol. 31, No. 5, pp. 276). Research Department of the Swedish National Board of Occupational Safety and Health, S-17184, Solna, Sweden.

Kirwan, B. and Ainsworth, L.K. (1992). *A Guide to Task Analysis.* London: Taylor and Francis.

Kjellberg, A., and Landstrom, U. (1994). Noise in the Office: Part I - Guidelines for the Practitioner. *International Journal of Industrial Ergonomics* (Vol. 14, pp. 87-91).

Kjellberg, A., and Landstrom, U. (1994). Noise in the Office: Part II - The Scientific Basis (Knowledge Base) for the Guide. *International Journal of Industrial Ergonomics* (Vol. 14, pp. 93-118).

Klemmer, A. P., Klemmer, R. N. (1934). "Subacute Caterial Endocarditis", *International Record of Medicine*. Taubman Medical.

Konz, S. (1994). Standing. *Ergonomics* (Vol. 37, No. 4, pp. 677).

Kumar, S., (1995). "Development of Predictive Equations for Lifting Strength," *Applied Ergonomics* (Vol. 26, No. 5, pp. 327 - 341).

Kumar, S., Narayan, Y., and Bacchus, C. (1995, December). Symmetric and Asymmetric Two-Handed Pull-Push Strength of Young Adults. *Human Factors* (Vol. 37, No. 4).

Kuorinka, I., and Koshinen, P. (1979). Occupational Rheumatic Diseases and Upper Limb Strain in Manual Jobs in a Light Mechanical Industry. *Scandinavian Journal of Work, Environment & Health* (Vol. 5, No. 3, pp. 39-47).

Kuorinka, Jonsson, Vinterberg, H., Biering-Soressen, F., Andersson, and Jorgensen, K. (1987, September). Standardized Nordic Questionnaires for the Analysis of Musculoskeletal Symptoms. *Applied Ergonomics. (*pp. 233-237).

Landis, R. and Koch, G. (1977) The Measurement of Observer Agreement for Categorical Data. *Biometrics* (Vol. 33, pp. 159-174).

Lavender, S., Thomas, J., Chang, D., and Andersson, B. (1995, December) Effect of Lifting Belts, Foot Movement, and Lift Asymmetry on Trunk Motions. *Human Factors* (Vol. 37, No. 4*).*

Levy, Finn and Ramberg, Ingrid.(1986) Eye Fatigue among VDU Users and Non-VDU Users. In *Proceedings of the International Scientific Conference: Work With Video Display Units.*(pp. 42-52) Swedish National Board of Occupational Safety and Health Research Department

Lewis, W.G., Narayan, C.V. (October 1993). Design and Sizing of Ergonomic Handles for Hand Tools. *Applied Ergonomics* .

Lifshitz, Y., and Armstrong, T. (1986). A Design Checklist for Control and Prediction of Cumulative Trauma Disorder in Intensive Manual Jobs. In *Proceedings of the Human Factors Society 30th Annual Meeting.* (pp. 945-950).

Linton, S., Kamwendo, K. (1989, July). Risk Factors in the Psychosocial Work Environment for Neck and Shoulder Pain in Secretaries. *Journal of Occupational Medicine* (Vol. 31, No. 7).

Loricchio, D., and Lewis, J. (1991) User Assessment of Standard and Reduced-Size Numeric Keypads. *Proceedings of the Human Factors Society 35th Annual Meeting-1991.*

Loslever, P., and Ranaivosoa, A. (1993). Biomechanical and Epidemiological Investigation of Carpal Tunnel Syndrome at Workplaces with High Risk Factors. *Ergonomics* (Vol. 36, No. 5, pp. 537-554).

Luczak, H., Cakir, A., Cakir, G. (1992, Sept. 1-4). Work with Display Units 92, Selected In *Proceedings of the Third International Scientific Conference on Work with Display Units*. Berlin, Germany.

Maclure, M. and Willet, W. C. Misinterpretation and Misuse of the Kappa Statistic. *American Journal of Epidemiology* (Vol. 126, No. 2, pp. 161-169).

Marley, R. and Kumar, N. (1996). An Improved Musculoskeletal Discomfort Assessment Tool. *International Journal of Industrial Ergonomics.* (Vol. 17, pp. 21-27).

Marquie, B.T., and Baracat, B. (1994). Age Influence on Attitudes of Office Workers Faced with New Computerized Technologies. *Applied Ergonomics* (Vol. 25, No. 3, pp. 130).

Marras, W.S., Leurgans S.E., Lavender, S.A., Allread, G.S., Fathallah, F.A., Ferguson, S.A., Rajulu, S.L. (1993) "Three Dimensional Dynamic Trunk Motions, Workplace Factors, and Occupational Low Back Disorders," *The Ergonomics of Manual Work*, Taylor and Francis, Ltd. London.

Mattila, M., Karwowski, W., and Vilkko, M. (1993, December). Analysis of Working Postures in Hammering Tasks on Building Construction Sites Using the Computerized OWAS Method. *Applied Ergonomics* (Vol. 24, No. 6).

McAtammey, L., and Corlett, E.N. (1993). RULA - A Survey Method for the Investigation of Work Related Upper Limb Disorders. *Applied Ergonomics* (Vol. 24, No. 2, pp. 91-99).

Meister, D. (1985). *Behavioral Analysis and Research Methods.* New York: John Wiley and Sons.

Military Standard 1472. Human Engineering Design Criteria for Military Systems, Equipment & Facilities.

Mital, A., and Asfour, S.S. (1983). Maximum Frequencies Acceptable to Males for One-Handed Lifting in the Sagital Plane. *Human Factors* (Vol. 25, No. 5, pp. 563-571).

Mital, A., and Manivasagan, I. (1983). Maximum Acceptable Weight of Lift as a Function of Material Density, Center of Gravity Location, Hand Preference, and Frequency. *Human Factors* (Vol. 25, No. 1, pp. 33-42).

Mital, A., Foononifard, H., and Brown, M.L. (1994, June). Physical Fatigue in High and Very High Frequency Manual Handling - Perceived Exertion and Physiological Indicators. *Human Factors* (Vol. 36, No. 2, pp. 219-231).

Mital, A., Nicholson, A.S., and Ayoub, M.M. (1993). *A Guide to Manual Materials Handling.* London: Taylor & Francis.

Moore, J. (1994, December 1-2). *The Epidemiological Context of Upper Extremity Disorders Associated with Work.* International Conference on Occupational Disorders of the Upper Extremities.

Nachemson, A. and Elfstrom, G. (1970) Intravital Dynamic Pressure Measurements in Lumbar Discs. *Scandinavian Journal of Rehabilitation Medicine - Supplement I.*

Nagamachi, M. (1995, Jan.) Engineering: A New Ergonomic Consumer-Oriented Technology for Product Development. *International Journal of Industrial Ergonomics* (Vol. 15, No. 1, pp. 3-11).

Nelson, J.B., and Mital A. (1995). An Ergonomical Evaluation of the Primary Hand Flexibility and Capability Changes with Increases in Examination/Surgical Glove Thickness. *Ergonomics* (Vol. 38, No. 4, pp. 723-734).

Nichols, H.M. (1967). Anatomic Structures of the Thoracic Outlet. *Clinical Orthopaedics and Related Research* (Vol. 51, pp. 17-25).

Ohara, H., Aoyama, H., Itani, T., Nakagiri, S., and Wake, K (1976). Occupational Health Hazards Resulting from Elevated Work Rate Situations. *Journal of Human Ergology* (Vol. 5, pp. 173-182).

OSHA Draft Ergonomic Protection Standard (listed as a risk factor in OSHA's Workplace Risk Factor Checklist).

Pascarelli, E., and Kella, J. (1993, May). Soft-Tissue Injuries Related to Use of the Computer Keyboard: A Clinical Study of 53 Severely Injured Persons. *Journal of Occupational Medicine* (Vol. 35, Number 5, pp. 522-532).

Putz-Anderson, V., (1992). *Cumulative Trauma Disorders: A Manual for Musculoskeletal Diseases of the Upper Limb.* Thoracic Taylor & Francis., London. (pp. 52).

Putz-Anderson, V., (1992). *Cumulative Trauma Disorders: A Manual for Musculoskeletal Diseases of the Upper Limb.* Thoracic Taylor & Francis., London. (pp. 23).

Putz-Anderson, V., (1992). *Cumulative Trauma Disorders: A Manual for Musculoskeletal Diseases of the Upper Limb.* Thoracic Taylor & Francis., London. (pp. 66).

Putz-Anderson, V., (1992). *Cumulative Trauma Disorders: A Manual for Musculoskeletal Diseases of the Upper Limb.* Thoracic Taylor & Francis., London (pp. 68-69).

Rempel, D., Gerson, J., Armstrong, T., Foulke, J., and Martin, B. (1991). Fingertip Forces while Using Three Different Keyboards. In *Proceedings of the Human Factors Society-35th Annual Meting.*

Rempel, D., Honan, M., Serina, E., and Tal, R. (1994) Wrist Postures While Typing on a Split Keyboard at Different Heights. *International Conference of Occupational Disorders of the UE.*

Repetition Strain Symptoms and Working Conditions Among Keyboard Workers Engaged in Data Entry or Word Processing in the South Australian Public Service. South Australian Health Commission, Epidemiology Branch, Occupational Health Branch. (1984, May).

Reynolds, J.L., Drury, C.G., and Broaderick, R.L. (1994). A Field Methodology for the Control of Musculoskeletal Injuries. *Applied Ergonomics.* (Vol. 25, No. 1, pp. 3-16).

Ridyard, D.T., Bobick, T.G., and Starkman, B.S. (1990, November). Ergonomics Awareness Training for Workplace Design Engineers. *Applied Ergonomics Technology, and NIOSH, Applied Occupational and Environmental Hygiene* (Vol. 5, No. 11, pp. 771-781).

Ryan, G.A., (1989). "Musculoskeletal Symptoms in Supermarket Workers," *Ergonomics* (Vol. 32, No. 4, pp. 359 - 371).

Sauter, S., Swanson, N. (1994, December). *Keyboard Work, Stress and Upper Limb Disorders.* National Institute for Occupational Safety and Health.

Sawin, D., and Scerbo, M. (1995, December). Effects of Instruction Type and Boredom Proneness in Vigilance: Implications for Boredom and Workload. *Human Factors* (Vol. 37, No. 4).

Schulze, J.H. L., Congleton, J.J., Koppa, R.L., Huchingsonm R.D. (1994, August). Effects of Pneumatic Screwdrivers and Workstations on Inexperienced and Experienced Operator Performance. *International Journal of Industrial Ergonomics* (Vol. 16, pp. 175-189).

Silverstein, B.A., Fine, L.J., and Armstrong, T.J. (1986). Hand Wrist Cumulative Trauma Disorders in Industry. *British Journal of Industrial Medicine* (Vol. 43, pp. 779-782).

Silverstein, B.A., Richards, S., Alcser, K., and Schurman, S. (1991). Evaluation of In-Plant Ergonomics Training. *International Journal of Industrial Ergonomics.*

Silverstein. B.A., Fine, L.J., and Armstrong, T.J. (1987). Occupational Factors and Carpal Tunnel Syndrome. *American Journal of Industrial Medicine* (Vol. 11, pp. 343-358).

Smith, M.J., Carayon, P., Sanders, K.J., Lim, S.Y., and LeGrande, D. (1992). Employee Stress and Health Complaints in Jobs With and Without Electronic Performance Monitoring. *Applied Ergonomics* (Vol. 23, No. 1, pp. 17-27).

Snook , S.H., Ciriello, V.M., (1991). "The Design of Manual Materials Handling Tasks: Revised Tables of Maximum Acceptable Weights and Forces." *Ergonomics* (Vol. 34, No. 9., pp. 1210).

Snook, S., Vaillancourt, D., Ciriello, V., and Webster, B. (1994, April 15). Psychophysical Studies of Repetitive Wrist Flexion and Extension. *Ergonomics*.

Sommerich, C.M., McGlothlin, J.D., Marras, W.S. (1993). Occupational Risk Factors Associated with Soft Tissue Disorders of the Shoulder: A Review of Recent Investigations in the Literature. *Ergonomics* (Vol. 36, No. 6.)

Sperling, L., Sven, D., Wikstrom, L., Kilbom, A., and Kadefors, R. (1993). A Cube Model for the Classification of Work with Hand Tools and the Formulation of Functional Requirements. *Applied Ergonomics.*

Starr, J. Steven. Effects of Video Display Terminals in a Business Office. (1984) *Human Factors* (Vol 3. No. 356. p.354).

Stetson, D.S., Keyserling, W.M., Silverstein, B.A., and Leonard, J.A., (November 1991). "Observational Analysis of the Hand and Wrist: A Pilot Study." *Applied Occupational and Environmental Hygiene*. DOL & State of Washington (Vol. 6, No. 11, pp. 927 - 937).

Tanaka, S., McGlothlin, J. (1993). A Conceptual Quantitative Model for Prevention of Work-Related Carpal Tunnel Syndrome (CTS). National Institute for Occupational Safety and Health. *International Journal of Industrial Ergonomics.*

The Joyce Institute, (1990). Job Evaluation Checklist. *Practical Office Ergonomics.*

The Joyce Institute, (1995). Uniroyal Industrial and Office Ergonomics Checklists. Unpublished.

The Newsletter of the Center for Office Technology. (1992, September/October). (Vol. 8, No. 5).

Thomas, R. G., van Baar, C. E., and Van der Stee, M. J. (1995). Baggage Handling: Posture and the Design of Conveyors. *Applied Ergonomics* (Vol. 26, No. 2, pp. 123-127).

Tyson, R.R., and Kaplan, G.F. (1975). Modern Concepts of Diagnosis and Treatment of the Thoracic Outlet Syndrome. *Orthopaedics Clinics of North America* (Vol. 6, pp. 507-519).

U. S. Department of Labor, Occupational Safety and Health Administration, (1995) *Draft Ergonomics Protection Standard.* Washington, D. C.

U. S. Department of Labor, Occupational Safety and Health Administration, (1970). *Occupational Safety and Health Act and Implementing Regulations.* Washington, D.C.

U.S. Department of Labor. Division of Occupational Analysis, United States Employment Service, Employment & Training Administration- *Guide to Job Analysis. A "How-to" Publication for Occupational Analysts.* Washington, D. C.

U.S. Department of Labor. (1991) *Dictionary of Occupational Titles.* Washington, D. C.

Ulin, S.S., Armstrong, T.J., Snook, S.H., Monroe-Keyserling, W. (1993). Examination of the Effect of Tool Mass and Work Postures on Perceived Exertion for a Screw Driving Task," *International Journal of Industrial Ergonomics* (Vol. 12, pp. 105-115).

Van Wely, P. (1970). Design and Disease. *Applied Ergonomics* (Vol. 1, No. 5, pp. 262-269).

Washburn, R.A. and Montoye, H.J. (1986). The Assessment of Physical Activity by Questionnaire. *American Journal of Epidemiology* (Vol. 123, No. 4, pp. 563 to 575).

Waters, T., V. Putz-Anderson., A.Garg,. (1994). *Applications Manual for the Revised NIOSH Lifting Equation.* U.S. Department of Health & Human Services, Centers for Disease Control, Cincinnati, Ohio

Wells, J.A., Zipp, J.F., Schuetter, P.T. and McEleney, J., (1983). "Musculoskeletal Disorders Among Letter Carriers". *Journal of Occupational Medicine* (pp. 814-820), as cited in Sommerich, C.M., McGlothlin, J. D., Marras., W. S. , (1993). "Occupational Risk Factors Associated with Soft Tissue Disorders of the Shoulder: A Review of Recent Investigations in the Literature". *Ergonomics* (Vol. 36, No. 6, pp. 697-717).

Wells, R. (1994, December 1-2). Biomechanical Models of CTD's/International Conference on Occupational Disorders of the Upper Extremities. Faculty of Applied Health Sciences, University of Waterloo, Ontario, Canada.

Wiker, S.F., Chaffin, D.B., Langolf, G.D. (1989). "Shoulder Posture and Localized Muscle Fatigue and Discomfort", *Ergonomics* (Vol. 32, No. 2).

Wiktorin, C., et al. (1991). Design and Reliability of a Questionnaire for Estimating of Physical Load on Epidemiological Studies. In *Proceedings of International Ergonomics Association* (199: 230-232).

Wiktorin, C., Karlqvist, L., et al. (1993). Validity of Self-Reported Exposures to Work Postures and Manual Materials Handling. *Scandinavian Journal of Work, Environment & Health* (Vol. 19, pp. 208-214).

APPENDIX A

Gold Standard Ergonomists
Qualification Summaries

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Biography

Jeffrey B. Nelson

Mr. Nelson, MSIE, is a consultant for The Joyce Institute, a unit of Arthur D. Little specializing in industrial and office consulting and training and in the design of consumer products for industrial and home environments. He has extensive experience in office product manufacturing, automobile assembly, semiconductor and clean room environments, and the chemical and consumer product industries.

Industrial Workplace Consulting: Ergonomics Assessment and Design

- For a modular housing fabricator in Mexico, Mr. Nelson designed a "super jig" for use in the construction of modular housing, and evaluated and critiqued the prototype of the machine.

- For a major hospital, he evaluated the stresses caused during plasma vial inspection. His recommendations included the redesign of a new "reject" holding cart, the adjustment of a lighting screen, the relocation of task lighting, the implementation of a worker rotation procedure, and the balancing of line speeds.

- For a corrugated box manufacturer, Mr. Nelson identified the stressors placed on workers involved in a box assembly procedure. He recommended process improvements and equipment modifications, including the relocation of controls, scheduled employee rotation, and the purchase of manual lifting devices. He also recommended the purchase of automated folding equipment, and created a design for a stationary folding apparatus.

- He evaluated a rotational molding operation, and recommended process revisions as well as design modifications for a platform and several tools and molds.

- For a sewage disposal facility, Mr. Nelson identified the musculoskeletal stressors placed on workers involved in the transfer of motor oil between containers. He recommended the purchase of a manual siphon pump to eliminate static loading on the shoulder, which was occurring during the performance of several tasks.

- For the U.S. Postal Service, Mr. Nelson evaluated the mechanized bulk mail sorting/delivery operation. He recommended lighting adjustments for all tasks, provision of anti-fatigue matting, adjustment of keypad features for workers at standing workstations, creation of a company-wide job/worker rotation policy, workstation redesign to facilitate movement and enable the use of both hands,

substitution of manual keypad entry with a bar-code reading system, and the purchase of headsets and adjustable chairs for control room monitors. He also recommended the incorporation of advanced ergonomics analysis techniques into future design.

Office Workplace Consulting: Ergonomics Assessment and Design

- For a regional hospital, Mr. Nelson recommended improvements to the Critical Care, Histology and Transcription Departments. His recommendations resulted in the redesign of work areas for enhanced visibility, alleviation of psychosocial stresses and increased desk space. He also recommended the automation of certain activities to reduce stresses to the upper limbs and remove external trauma; and recommended the development of policy covering workload distribution, workstation layout and materials placement.

- For a hospital, Mr. Nelson redesigned a medical records storage facility. His recommendations included the installation of new equipment and the redesign of out-patient records facility.

- For a large technology firm, Mr. Nelson developed a manual that instructs computer input device users in how to improve their workstation layout, body orientation and work habits by incorporating ergonomics principles. For the manual, he created a customized checklist to reinforce these principles on an ongoing basis through the use of exercises and strategies to increase comfort.

- For a railway management office where there had been workplace injuries, he identified stressors and recommended improvements including the equipment purchase, institution of formal evaluation procedures, redesign of work areas and suggested design for future space planning efforts, training in office ergonomics.

- Mr. Nelson evaluated physical and psychosocial issues involved with an aerospace-industry office worker who had been diagnosed Fibromyalgia. His recommendations included workstation redesign and enhancements, education about Fibromyalgia, broadening of the worker's job to include greater responsibility and variety of tasks, and training in office ergonomics.

Product Design Criteria Development for End-User

- For a multinational computer design firm, Mr. Nelson developed criteria to be used in the development of a computer input device. The criteria will allow for movement control in all planes, force feedback, without causing potential injury.

Training Design and Implementation

- For the U.S. Postal Service, Mr. Nelson developed and implemented customized ergonomics course material, addressing those ergonomics stressors for tasks involving sitting, standing and materials handling.

- Mr. Nelson has trained employees in ways to identify, alleviate and prevent workplace ergonomics hazards at numerous industrial and office firms, including a chemical manufacturer, an electrical component/semiconductor manufacturer, an electronic test equipment manufacturer, a hospital equipment manufacturer, newspaper printing and publishing companies, manufacturers of office, vinyl and paper products, an international petrochemical company, a major pharmaceuticals firm, a pulp and paper processor, a seafood processor, a manufacturer of silicon wafers, a truck manufacturer and a wood and steel cabinet construction firm.

Education/Professional Activities

Mr. Nelson received a Master of Science in Industrial Engineering, specializing in Industrial Ergonomics, from the University of Cincinnati in Ohio. He holds a Bachelor of Science in Kinesiology, specializing in Biomechanics, Neurology and Physiology from the University of California at Los Angeles.

He is a member of the Human Factors and Ergonomics Society and the American Society of Safety Engineers.

Publications

Nelson, Jeffrey B. and Anil Mital, "An Ergonomical Evaluation of the Primary Hand Flexibility and Capability Changes with Increases in Examination/Surgical Glove Thickness," *Ergonomics*, Vol. 38, No. 4, April 1995.

Presentations

Nelson, J. B. and Joyce, M. "Measuring the Results of Ergonomics Training," ErgoCon, San Jose CA, May 1995.

Nelson, J. B., and Joyce, M. "Computer Related Injuries: Ergonomics and OSHA Guidelines," Society of Architectural Administrators, Los Angeles CA, May 1994.

Nelson, J. B. and Joyce, M. "Ergonomics," Western Safety Congress, Anaheim CA, May 1994.

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Biography

Linda Miller

Ms. Miller is an Ergonomics Consultant for The Joyce Institute, a unit of Arthur D. Little, as an Associate/Contract employee, specializing in industrial and office consulting and throughout Canada. She has experience in the meat and poultry, forestry, office, and hospital industries.

Ergoworks, Inc.: Ergonomic Consulting and Training

- Provides training and consulting services to major industries in Canada in forestry, mining, manufacturing, telecommunications, and others.
- Conducts workplace evaluations, job analyses, records review services.
- Develops custom software to track injuries/illnesses and to match job requirements with individual physical capabilities.

Workers Compensation Board: Ergonomic Consulting

- Provide ergonomic work site consultations: (Rehabilitated Worker and full workstation assessments - main focus on meat and poultry, forestry, office, and hospital industries)
- Provide Office Ergonomic presentations to employees and supervisors.
- Participated in the Ergonomics Pilot Program (WCB Employees) and reviewed injury/accident data, production and error rates, and symptoms questionnaire results to determine need for ergonomics.

Ergonomics Research and Design: Research Assistant

- Conducted a review of accident/incident data for the Canadian Petroleum Association.
- Provided work site evaluation and assisted protocol development.

Calgary General Hospital: Occupational Therapist

- Assessment and treatment of physical dysfunction
- Participated in the development of devices to assist the physically handicapped.
- Assisted in design of the seniors' park near hospital.

Healthworks, Inc.: Ergonomic Consultant

- Developed protocol to assess manual material handling.
- Provided ergonomic assessment of Alberta Liquor Control Board Stores and warehouse operations.
- Developed recommendations to mitigate identified ergonomic risk factors.

Education/Professional Activities

Ms. Miller received a M.E. Des. specializing in Environmental Science, from the University of Calgary. He holds a Bachelor of Science in Occupational Therapy (honors with distinction), from the University of Alberta.

She is a member of the HFAC/ACE.

Publications

Miller, L., Wardell, R. and Village, J. (1992). The Ergonomic Process - A Case Study in a Northern Alberta Lumbermill. Proceedings of Human Factors Association of Canada. Hamilton, Ontario.

Wardell, R.W., Village, J. and Miller, L. (1992). Back Injuries in the Oil and Gas Industry. Proceedings of Human Factors Association of Canada. Hamilton, Ontario.

Miller, L. (1992). A Bathroom Sink Design for the Physically Disabled. Proceedings of Interface Conference. Dayton, Ohio. Human Factors Society.

Presentations

Wardell, R.W., Miller, L.L. and Corbet, K. (1994). Ergonomics in the Oil and Gas Industry - 5 day seminar. University of Calgary. Calgary, Alberta. (Co-presentor)

Miller, L.L. (1993). Setting up an Ergonomics Program. Alberta Association of Safety Engineers. Edmonton, Alberta. (Presentor)

Miller, L., Wardell, R. and Village, J. (1992). The Ergonomic Process - A Case Study in a Northern Alberta Lumbermill. Proceedings of Human Factors Association of Canada. Hamilton, Ontario. (Presentor)

Miller, L. (1991). A Bathroom Sink Design for the Physically Disabled. Proceedings of Interface Conference. Dayton, Ohio. Human Factors Society. (Presentor)

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APPENDIX B

Alpha Test Results Suggested the following changes to enhance usability.

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Table B
Alpha Test Results Suggested the Following Changes to Enhance Usability

Methodology Component	Issue	Change	Expected Benefit
Level I Checklist, Cover Page	Lack of method for integrating information obtained from the JR/PD Survey.	Added a cover page and section into which technician can transfer/record "Work Type" information from Part III of the Survey. Header and footer on cover page uses the same format and collects the same demographics information as the Survey.	Will help technician focus application of the Methodology to the job/task types routinely performed employees in the shop. Shop and demographics information will enable the Air Force to make comparisons between JR/PD Survey and Level I Methodology results.
Level I Checklist, Part II - Job Factors	Inconsistency and possible confusion created by not labeling "F" (Frequently) and "S" (Sometimes) responses within the response boxes for each Job Factor question.	Responses modified to; "F=4" (or F=2) and "S=1" within each box. "F" and "S" headings removed from the header row.	

Table B (Cont'd)

Methodology Component	Issue	Change	Expected Benefit
	Changes to the Checklist Scoring Summary and method for establishing risk/priority eliminate the need for calculating "Job Factor Scores" across tasks.	Eliminated the "Job Factor Scores" column.	Increases speed of scoring by remove redundant or unnecessary calculations.
	"No place to rest hands..." question (Hands/Wrists/Arms section) is a "cause" rather than a "job/risk" factor.	Question 14 was eliminated.	Improves consistency to "risk factor" focus for each Job Factor question. Eliminates potential for overstatement of risk factor exposure for the Hands/Wrists/Arms.
	Possible under-representation of back/torso risk factors for seated work. Possible over-representation or legs/feet risk factors.	Since the lack of foot support can have the most significant impact on the lower back, and since the "Edge of Seat..." question in the Legs/Feet section represents the mechanical stress risk factor, the "No Foot Support" question from the Legs/Feet section was moved to the Back/Torso section.	Will achieve a more complete representation of Back/Torso risk factors for seated employees and eliminate risk factor redundancy for the Legs/Feet.

Table B (Cont'd)

Methodology Component	Issue	Change	Expected Benefit
Checklist Scoring Summary, Section 2, Scoring Summary	Possible confusion created from "Task" and "Body Region" scoring summary boxes on the bottom of the scoring document.	Provide separate scoring summary boxes for "First Priority" and "Second Priority" Tasks. Provide spaces for "First Highest" and "Second Highest" body region scores within each box.	Provides better grouping of summary information. Will help technician select appropriate Case Studies and keep focus of problem-solving on the highest priority body regions.
Corrective Action List	Too much page turning when using the Corrective Actions List to record controls suggested in the Case Study Problem-Solving Matrices.	Re-format Corrective Actions List to reduce pages from 5 to 3.	Increase the speed for recording controls when using the Case Study Problem-Solving Matrices.
User Instructions	Ergonomists reported that User Instructions were clear.	Small formatting improvements were made.	Improve readability or User Instructions.
Case Study Problem-Solving Matrices	Ergonomists reported that the Matrices were clear and easy to use.	No changes were made except for additions to the content and detail for control options. (This was an intended secondary objective of the Alpha Test using ergonomists.)	Enable technicians to select from control options provided based on the combined experience of 5 ergonomists.

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APPENDIX C

Raw Data; Alpha and Beta Test

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Elapsed Time (min.)			
Subject	**Scenario**	**Checklist**	**Summary**
Karen	1	38	22
Pat	1	20	25
Jennifer	1	5	10
X	1	9	18
Altadawn	1	12	15
Joe	1	13	8
William	1	10	10
Glisson	1	10	10
Dennis	1	15	20
Judith	1	25	45
Karen	2	22	23
Pat	2	40	20
Jennifer	2	10	10
X	2	12	20
Altadawn	2	16	18
Joe	2	25	17
William	2	20	15
Glisson	2	30	30
Dennis	2	10	20
Judith	2	17	16
Karen	3	18	20
Pat	3	20	40
Jennifer	3	10	5
X	3	28	20
Altadawn	3	20	20
Joe	3	25	14
William	3	20	15
Glisson	3	15	10
Dennis	3	10	15
Judith	3	22	
Karen	4	37	19
Pat	4	30	25
Jennifer	4	15	10
X	4	30	20
Altadawn	4	19	20
Joe	4	27	17
William	4	20	15
Glisson	4	20	30
Dennis	4	15	15

Time

Elapsed Time (min.)			
Subject	**Scenario**	**Checklist**	**Summary**
Judith	4	18	21
Karen	5	16	20
Pat	5	14	10
Jennifer	5	20	10
X	5	28	20
Altadawn	5	20	15
Joe	5	95	35
William	5	50	30
Glisson	5	10	
Dennis	5	5	5
Judith	5	13	18
Karen	6	29	21
Pat	6	13	13
Jennifer	6	20	25
X	6	20	20
Altadawn	6	22	19
Joe	6	35	25
William	6	40	30
Glisson	6	25	20
Dennis	6	15	25
Judith	6	27	23
Karen	7	15	15
Pat	7	15	17
Jennifer	7	7	7
X	7	22	14
Altadawn	7	13	9
Joe	7	20	13
William	7	15	15
Glisson	7	25	20
Dennis	7	15	10
Judith	7	7	10
Karen	8	14	12
Pat	8	22	25
Jennifer	8	15	15
X	8	26	28
Altadawn	8	15	11
Joe	8	15	10
William	8	25	30
Glisson	8	15	10

Elapsed Time (min.)			
Subject	**Scenario**	**Checklist**	**Summary**
Dennis	8	10	10
Judith	8	25	10
Karen	9	19	24
Pat	9	40	45
Jennifer	9	15	10
X	9	30	30
Altadawn	9	40	33
Joe	9	25	15
William	9	25	20
Glisson	9	20	20
Dennis	9	15	15
Judith	9	17	18
Karen	10	18	18
Pat	10	20	20
Jennifer	10	20	15
X	10	30	28
Altadawn	10	15	13
Joe	10	30	10
William	10	30	30
Glisson	10	50	35
Dennis	10	20	15
Judith	10	17	19
Karen	11	15	6
Pat	11		10
Jennifer	11	8	7
X	11	21	20
Altadawn	11	10	4
Joe	11	15	7
William	11	20	15
Glisson	11	15	10
Dennis	11	5	5
Judith	11	10	11
	mean time	20.60550459	17.83333333
	standard Deviation	11.52052785	8.296491771

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		Overall Priority Rating	Actual	Comp. Use	Wrting Revw Docs	Stapln	Mntrng	Calling	Copy	Drftng CAD	Filing/ Gen Admin	Lifting	Calcltr Nmrc Keypd	Micro-scope	Hi-Risk Hands	Hi-Risk Shlder	Hi-Risk Head	Hi-Risk Legs	Hi-Risk Back	Med-Risk Hands	Med-Risk Shlder	Med-Risk Head
Subject	Scenario	IIa		IIb	IIb	IIb	IIb	IIb	IIb	IIb	IIb	IIb	IIb	IIb	IIc-1	IIc-2	IIc-3	IIc-4	IIc-5	IId-1	IId-2	IId-3
KAREN_F.	AD_01	13	.	13	.	.	.	.	.	.	.	.	.	.	13	.	.	.	.		6	7
KAREN_F.	AD_02	2	.	3	5	.	.	1	.	.	.	.	.	.	.	.	.	.	.			
KAREN_F.	AD_03	7	.	.	2	.	.	.	.	.	.	.	11	.	.	.	.	.	.	6		
KAREN_F.	AD_04	3	.	7	1	.	4	4	.	.	.	.	.	.	.	.	.	.	.			
KAREN_F.	AD_05	15	.	.	.	.	.	.	.	15	.	.	.	.	15	.	.	.	.			6
KAREN_F.	AD_06	6	.	5	.	.	.	.	.	.	12	4	.	.	.	.	.	.	.	5	6	
KAREN_F.	AD_07	8	.	.	.	.	8	.	.	.	.	.	.	.	.	.	8	.	.		5	
KAREN_F.	AD_08	3	.	.	4	3	.	.	.	.	.	.	.	.	.	.	.	.	.			
KAREN_F.	AD_09	8	.	3	13	.	.	.	.	.	.	.	.	.	8	8	.	.	.			
KAREN_F.	AD_10	3	.	5	2	.	.	2	.	.	.	.	.	.	.	.	.	.	.			
KAREN_F.	AD_11	7	.	.	.	.	.	.	.	.	.	.	.	15	.	.	.	.	.	7		
PAT_V.	AD_01	11	.	11	.	.	.	.	.	.	.	.	.	.	11	.	10	.	8			
PAT_V.	AD_02	7	15	4	15	.	.	3	.	.	.	.	.	.	.	.	.	.	.	7	5	
PAT_V.	AD_03	8	11	11	7	.	.	.	.	.	.	.	.	.	8	.	.	.	.		4	6
PAT_V.	AD_04	3	4	4	4	.	4	4	.	.	.	.	.	.	.	.	.	.	.		4	
PAT_V.	AD_05	4	.	.	.	.	.	.	.	4	.	.	.	.	.	.	.	.	.	4		4
PAT_V.	AD_06	9	19	6	.	.	.	.	.	.	19	5	.	.	12	.	.	.	.		6	
PAT_V.	AD_07	8	.	.	.	.	8	.	.	.	.	.	.	.	.	.	8	.	.			
PAT_V.	AD_08	5	.	.	5	5	.	.	.	.	.	.	.	.	.	.	.	.	.	5		
PAT_V.	AD_09	11	17	4	17	.	.	.	.	.	.	.	.	.	9	11	.	.	.			
PAT_V.	AD_10	8	13	9	13	.	.	4	.	.	.	.	.	.	8	.	.	.	.		6	
PAT_V.	AD_11	15	.	.	.	.	.	.	.	.	.	.	.	15	15	.	.	.	.		5	4
JENNIFER_F.	AD_01	7	.	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7	4	5
JENNIFER_F.	AD_02	1	2	2	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.			
JENNIFER_F.	AD_03	4	7	.	1	.	.	.	.	.	.	.	7	.	.	.	.	.	.	4		
JENNIFER_F.	AD_04	3	6	4	2	.	6	0	.	.	.	.	.	.	.	.	.	.	.			5
JENNIFER_F.	AD_05	8	.	.	.	.	.	.	.	8	.	.	.	.	8	.	.	.	.			4
JENNIFER_F.	AD_06	5	10	5	.	.	.	.	.	.	5	4	.	.	.	.	.	.	.			
JENNIFER_F.	AD_07	6	.	.	.	.	6	.	.	.	.	.	.	.	.	.	.	.	.			6
JENNIFER_F.	AD_08	6	8	.	4	8	.	.	.	.	.	.	.	.	.	.	.	.	.	6		
JENNIFER_F.	AD_09	5	8	1	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
JENNIFER_F.	AD_10	3	8	8	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.			

Subject	Med-Risk Legs IId-4	Med-Risk Back IId-5	Keying III-1	Writing III-2	Staple III-3	Mouse III-4	Mntmg III-5	Calling III-6	Cpying III-7	Drftng III-8	Filing III-9	Calcltr III-10	Lifting III-11	Micro-scope III-12	Score S N	Score HWA	Score Back	Score Legs	Score Head	Gold Std
KAREN_F.			1	.	.	.	.	.	.	.	.	.	.	.	6	13	0	0	7	3
KAREN_F.			1	.	.	.	.	1	.	.	.	.	.	.	2	1	0	0	2	1
KAREN_F.			1	1	.	.	.	.	.	.	.	1	.	.	2	7	3	0	3	2
KAREN_F.			1	.	.	.	1	1	.	1	.	.	.	.	3	2	0	3	3	3
KAREN_F.			1	1	.	1	1	.	.	1	.	.	.	.	1	15	0	0	6	2
KAREN_F.		6	1	.	.	.	.	.	.	.	1	.	1	.	6	6	6	1	1	2
KAREN_F.			1	.	.	.	1	.	.	.	.	.	.	.	5	3	1	0	8	3
KAREN_F.			.	.	1	.	.	.	1	.	.	.	.	.	2	4	1	0	1	2
KAREN_F.			1	1	.	1	1	.	1	.	.	.	.	.	8	8	3	0	3	2
KAREN_F.		4	1	1	.	1	.	1	.	.	.	.	.	.	2	2	3	0	2	2
KAREN_F.			.	.	.	.	.	.	.	.	.	.	.	1	0	15	1	0	1	3
PAT_V.	4		1	.	.	.	.	.	.	.	.	.	.	.	2	11	8	4	10	3
PAT_V.			.	1	.	.	.	.	.	.	.	.	.	.	5	7	4	2	3	1
PAT_V.	4	4	1	.	.	.	.	.	.	.	.	.	.	.	4	8	4	4	6	2
PAT_V.			.	.	.	.	1	.	.	.	.	.	.	.	3	1	2	3	2	3
PAT_V.			.	.	.	.	.	.	.	1	.	.	.	.	1	4	0	0	4	2
PAT_V.		6	.	.	.	.	.	.	.	.	1	.	.	.	6	9	6	3	2	2
PAT_V.			.	.	.	.	1	.	.	.	.	.	.	.	2	0	2	2	8	3
PAT_V.			.	.	1	.	.	.	.	.	.	.	.	.	2	5	2	1	2	2
PAT_V.			.	1	.	.	.	.	.	.	.	.	.	.	11	9	3	3	1	2
PAT_V.			.	1	.	.	.	.	.	.	.	.	.	.	6	8	3	0	2	2
PAT_V.		4	.	.	.	.	.	.	.	.	.	.	.	1	5	15	4	1	4	3
JENNIFER_F.		4	1	.	.	.	.	.	.	.	.	.	.	.	4	7	4	0	5	3
JENNIFER_F.			1	1	.	.	.	1	.	.	.	.	.	.	1	1	0	0	1	1
JENNIFER_F.			.	1	.	.	.	.	.	.	.	1	.	.	1	4	0	0	1	2
JENNIFER_F.			1	1	.	.	1	1	.	.	.	.	.	.	2	1	0	0	3	3
JENNIFER_F.			.	.	.	.	.	.	.	1	.	.	.	.	0	8	0	0	4	2
JENNIFER_F.	5		1	.	.	.	.	.	.	.	1	.	1	.	3	0	3	5	1	2
JENNIFER_F.			.	.	.	.	1	.	.	.	.	.	.	.	1	0	1	0	6	3
JENNIFER_F.			.	1	1	.	.	.	.	.	.	.	.	.	2	6	0	0	1	2
JENNIFER_F.			1	1	.	.	.	.	.	.	.	.	.	.	3	2	5	0	1	2
JENNIFER_F.			1	1	.	.	.	1	.	.	.	.	.	.	1	0	3	0	1	2

Subject	Scenario	Overall Priority Rating IIa	Actual	Comp. Use IIb	Wrtng Revw Docs IIb	Stapln IIb	Mntrng IIb	Calling IIb	Copy IIb	Drftng CAD IIb	Filing/ Gen Admin IIb	Lifting IIb	Calcltr Nmrc Keypd IIb	Micro-scope IIb	Hi-Risk Hands IIc-1	Hi-Risk Shlder IIc-2	Hi-Risk Head IIc-3	Hi-Risk Legs IIc-4	Hi-Risk Back IIc-5	Med-Risk Hands IId-1	Med-Risk Shlder IId-2	Med-Risk Head IId-3
JENNIFER_F.	AD_11	1												1								
UNKNOWN	AD_01	8		8													8				4	
UNKNOWN	AD_02	4	7	7	6			2												4		4
UNKNOWN	AD_03	7	12		2								2		7							
UNKNOWN	AD_04	4	6	6			6	2														4
UNKNOWN	AD_05	9								9					9		8					
UNKNOWN	AD_06	3		4								4										
UNKNOWN	AD_07	9					9										9			4	6	
UNKNOWN	AD_08	9	13		4	13									8						4	
UNKNOWN	AD_09	10	9	5	14											10				7		5
UNKNOWN	AD_10	4	7	7	4			1												4		
UNKNOWN	AD_11	5																		5	5	
ALTADAWN	AD_01	16		16											16	9						6
ALTADAWN	AD_02	6		3	15			3												6	6	
ALTADAWN	AD_03	13			8								17		13						6	
ALTADAWN	AD_04	6		12	9		6	4												5	6	4
ALTADAWN	AD_05	8								8							8			7	4	
ALTADAWN	AD_06	12		12							16	12			12	12						
ALTADAWN	AD_07	12					12									12				4		6
ALTADAWN	AD_08	18			15	20									18						7	4
ALTADAWN	AD_09	9		9	10										8	9						4
ALTADAWN	AD_10	8		9	12			4								8				5		
ALTADAWN	AD_11	9												9	9						5	
JOE_Z.	AD_01	12		12												12	8		8			
JOE_Z.	AD_02	5	8	7	4			8													5	
JOE_Z.	AD_03	6	11		4								11							5	6	4
JOE_Z.	AD_04	6	8	8	8		5	4												4	5	4
JOE_Z.	AD_05	7								7										7		6
JOE_Z.	AD_06	13		17	12						16				10	13			11			
JOE_Z.	AD_07	6					6													5	5	6
JOE_Z.	AD_08	7			7	7														7	4	4
JOE_Z.	AD_09	6	8	5	8																5	4

Subject	Med-Risk Legs IId-4	Med-Risk Back IId-5	Keying III-1	Writing III-2	Staple III-3	Mouse III-4	Mntrng III-5	Calling III-6	Cpying III-7	Drftng III-8	Filing III-9	Calcltr III-10	Lifting III-11	Micro-scope III-12	Score S N	Score HWA	Score Back	Score Legs	Score Head	Gold Std
JENNIFER_F.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	0	1	1	0	0	3
UNKNOWN	.	.	1	.	.	.	.	.	.	.	.	.	.	.	4	2	0	0	8	3
UNKNOWN	.	.	1	.	.	.	.	.	.	.	1	.	.	.	0	4	2	0	4	1
UNKNOWN	.	.	.	.	.	.	.	.	.	.	1	1	.	.	1	7	2	0	2	2
UNKNOWN	.	4	1	.	.	.	1	1	.	.	.	.	.	.	3	2	4	0	4	3
UNKNOWN	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1	9	0	0	8	2
UNKNOWN	.	.	1	.	.	.	.	.	.	.	.	.	1	.	2	2	3	2	3	2
UNKNOWN	.	.	.	.	.	.	1	.	.	.	.	.	.	.	6	4	2	0	9	3
UNKNOWN	.	.	.	1	1	.	.	.	.	.	.	.	.	.	4	9	1	0	1	2
UNKNOWN	.	4	1	1	.	.	.	.	.	.	.	.	.	.	9	7	4	0	5	2
UNKNOWN	.	.	1	1	.	.	.	1	.	.	.	.	.	.	1	4	0	1	2	2
UNKNOWN	.	4	.	.	.	.	.	.	.	.	.	.	.	1	5	5	4	0	2	3
ALTADAWN	.	.	1	.	.	1	1	.	.	.	.	.	.	.	9	16	0	0	6	3
ALTADAWN	.	.	1	1	.	1	1	1	1	.	.	.	.	.	6	6	2	0	3	1
ALTADAWN	4	4	.	1	.	.	.	.	.	.	.	1	.	.	6	13	4	4	3	2
ALTADAWN	.	.	1	1	.	1	1	.	.	1	.	.	.	.	6	5	0	0	4	3
ALTADAWN	.	4	.	.	.	1	1	.	.	.	.	.	.	.	4	7	4	0	8	2
ALTADAWN	6	6	1	.	.	.	1	.	.	.	1	.	.	.	12	12	6	6	3	2
ALTADAWN	.	4	.	.	.	.	1	.	.	.	.	.	.	.	12	4	4	0	6	3
ALTADAWN	.	4	.	.	.	.	.	.	.	.	.	.	.	.	7	18	4	0	4	2
ALTADAWN	4	5	.	.	.	.	.	.	.	.	.	.	.	.	9	8	5	4	4	2
ALTADAWN	.	.	1	1	.	.	1	1	.	.	.	.	.	.	8	5	3	0	2	2
ALTADAWN	.	4	.	.	.	.	.	.	.	.	.	.	.	1	5	9	4	0	2	3
JOE_Z.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	12	3	8	0	8	3
JOE_Z.	.	4	1	1	.	.	.	1	.	.	.	.	.	.	5	1	4	0	3	1
JOE_Z.	.	4	.	1	.	.	.	.	.	.	.	1	.	.	6	6	4	0	4	2
JOE_Z.	.	5	1	1	.	.	1	1	.	.	.	.	.	.	6	5	5	0	4	3
JOE_Z.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	7	0	0	6	2
JOE_Z.	5	.	1	.	.	.	.	.	.	.	1	.	1	.	13	11	11	6	2	2
JOE_Z.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	5	5	1	1	6	3
JOE_Z.	4	.	.	.	1	.	.	.	.	.	.	.	.	.	4	7	2	4	4	2
JOE_Z.	.	6	1	1	.	.	.	.	.	.	.	.	.	.	5	1	6	0	4	2

		Overall Priority Rating	Actual	Comp. Use	Wrtng Revw Docs	Stapln	Mntrng	Calling	Copy	Drftng CAD	Filing/ Gen Admin	Lifting	Calcltr Nmrc Keypd	Micro-scope	Hi-Risk Hands	Hi-Risk Shlder	Hi-Risk Head	Hi-Risk Legs	Hi-Risk Back	Med-Risk Hands	Med-Risk Shlder	Med-Risk Head
Subject	**Scenario**	**IIa**		**IIb**	**IIb**	**IIb**	**IIb**	**IIb**	**IIb**	**IIb**	**IIb**	**IIb**	**IIb**	**IIb**	**IIc-1**	**IIc-2**	**IIc-3**	**IIc-4**	**IIc-5**	**IId-1**	**IId-2**	**IId-3**
JOE_Z.	AD_10	6		6	8			6													5	6
JOE_Z.	AD_11	12												12	12							4
WILLIAM_R.	AD_01	11		11											11							4
WILLIAM_R.	AD_02	3		4	5			1														
WILLIAM_R.	AD_03	6			4								8							6		
WILLIAM_R.	AD_04	2		5	1		5	0														
WILLIAM_R.	AD_05	6								6										5	4	6
WILLIAM_R.	AD_06	4		5							9	2									4	
WILLIAM_R.	AD_07	8					8										8					
WILLIAM_R.	AD_08	8			12	4									8						4	
WILLIAM_R.	AD_09	4		4	7															4		
WILLIAM_R.	AD_10	3		5	1			3														
WILLIAM_R.	AD_11	11												11	11							
GLISSON	AD_01	9		9											9	9						6
GLISSON	AD_02	3		3	5			2														
GLISSON	AD_03	8	11		4								11		8							
GLISSON	AD_04	6	8	8	3		4	8													5	
GLISSON	AD_05	7								7										7		4
GLISSON	AD_06	6	14	5							14	4									6	
GLISSON	AD_07	7					7										7		4			
GLISSON	AD_08	4			4	4														4		
GLISSON	AD_09	3		2	4																	
GLISSON	AD_10	5	8	8	5			4												5		
GLISSON	AD_11	15												15	15				8		4	6
DENNIS	AD_01	8		8											8							5
DENNIS	AD_02	3		3	6			2														
DENNIS	AD_03	5			5								5							4	4	4
DENNIS	AD_04	4		8	2		6	2														4
DENNIS	AD_05	12								12					12							4
DENNIS	AD_06	6		2							8	8									4	
DENNIS	AD_07	5					5														5	
DENNIS	AD_08	13			13	13									13						4	

Subject	Med-Risk Legs IId-4	Med-Risk Back IId-5	Keying III-1	Writing III-2	Staple III-3	Mouse III-4	Mntrng III-5	Calling III-6	Cpying III-7	Drftng III-8	Filing III-9	Calcltr III-10	Lifting III-11	Micro-scope III-12	Score S N	Score HWA	Score Back	Score Legs	Score Head	Gold Std
JOE_Z.	.	.	1	1	.	.	.	1	.	.	.	.	.	.	6	2	3	0	6	2
JOE_Z.	.	4	.	.	.	.	.	.	.	.	.	.	.	1	0	12	4	0	4	3
WILLIAM_R.	.	.	1	.	.	.	1	.	.	.	.	.	.	.	0	11	1	0	4	3
WILLIAM_R.	.	.	1	.	.	.	.	1	1	.	.	.	.	.	3	2	0	0	1	1
WILLIAM_R.	.	.	.	1	.	.	.	.	.	.	.	1	.	.	3	6	2	0	1	2
WILLIAM_R.	.	.	1	1	.	.	1	1	.	.	.	.	.	.	2	1	0	0	2	3
WILLIAM_R.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	5	0	0	6	2
WILLIAM_R.	.	.	1	.	.	.	.	.	.	.	1	.	1	.	4	0	2	7	2	2
WILLIAM_R.	.	4	.	.	.	.	1	.	.	.	.	.	.	.	2	1	4	0	8	3
WILLIAM_R.	.	.	.	.	1	.	.	.	1	.	.	.	.	.	4	8	0	0	0	2
WILLIAM_R.	.	4	1	.	.	.	.	.	1	.	.	.	1	.	2	4	4	0	1	2
WILLIAM_R.	.	.	1	1	.	.	.	1	.	.	.	.	.	.	3	1	0	0	1	2
WILLIAM_R.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	0	11	0	0	1	3
GLISSON	.	5	1	.	.	1	1	.	.	.	.	.	.	.	9	9	5	0	6	3
GLISSON	.	.	1	1	.	.	1	1	.	.	.	.	.	.	1	3	3	0	2	1
GLISSON	.	.	.	1	.	.	.	.	.	.	.	1	.	.	2	8	3	0	3	2
GLISSON	.	.	1	1	.	1	1	1	.	1	.	.	.	.	6	4	4	0	3	3
GLISSON	.	.	1	.	.	1	1	.	.	1	.	.	.	.	1	7	0	0	4	2
GLISSON	.	6	1	.	.	.	1	.	.	.	1	.	1	.	6	3	6	2	3	2
GLISSON	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	2	4	0	7	3
GLISSON	.	.	.	.	1	.	.	.	1	.	.	.	.	.	2	4	1	0	1	2
GLISSON	.	.	1	1	.	.	1	.	.	.	.	.	.	.	2	2	2	0	3	2
GLISSON	.	.	1	.	.	1	1	1	.	.	.	.	.	.	2	5	3	0	2	2
GLISSON	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	15	8	0	6	3
DENNIS	.	.	1	.	.	1	1	.	.	.	.	.	.	.	2	8	1	0	5	3
DENNIS	.	.	1	1	.	.	.	1	.	.	.	.	.	.	2	3	0	0	3	1
DENNIS	.	.	.	1	.	.	.	.	.	.	.	1	.	.	5	4	0	0	4	2
DENNIS	.	.	1	1	.	1	1	1	.	.	.	.	.	.	2	2	0	0	4	3
DENNIS	.	.	.	.	.	.	.	.	.	1	.	.	.	.	0	12	0	0	4	2
DENNIS	.	5	1	.	.	.	.	.	.	.	1	.	1	.	5	2	6	2	1	2
DENNIS	.	.	.	.	.	.	1	.	.	.	.	.	.	.	5	3	0	0	3	3
DENNIS	.	.	.	.	1	.	.	.	.	.	.	.	.	.	4	13	0	0	2	2

		Overall Priority Rating	Actual	Comp. Use	Wrting Revw Docs	Stapln	Mntrng	Calling	Copy	Drftng CAD	Filing/ Gen Admin	Lifting	Calcltr Nmrc Keypd	Micro-scope	Hi-Risk Hands	Hi-Risk Shlder	Hi-Risk Head	Hi-Risk Legs	Hi-Risk Back	Med-Risk Hands	Med-Risk Shlder	Med-Risk Head
Subject	**Scenario**	**IIa**		**IIb**	**IIb**	**IIb**	**IIb**	**IIb**	**IIb**	**IIb**	**IIb**	**IIb**	**IIb**	**IIb**	**IIc-1**	**IIc-2**	**IIc-3**	**IIc-4**	**IIc-5**	**IId-1**	**IId-2**	**IId-3**
DENNIS	AD_09	4	.	2	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DENNIS	AD_10	6	.	8	3	.	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DENNIS	AD_11	12	.	.	.	.	.	.	.	.	.	.	.	12	12	.	.	.	.	.	.	.
JUDITH	AD_01	13	.	13	.	.	.	.	.	.	.	.	.	.	13	13	8	.	8	.	.	.
JUDITH	AD_02	17	51	16	17	.	.	18	.	.	.	.	.	.	17	13	.	.	8	.	.	7
JUDITH	AD_03	19	38	.	14	.	.	.	.	.	.	.	24	.	19	.	.	.	.	.	7	5
JUDITH	AD_04	14	54	16	17	.	10	21	.	.	.	.	.	.	14	12	10	.	8	.	.	.
JUDITH	AD_05	19	.	.	.	.	.	.	.	19	.	.	.	.	19	.	10	.	.	.	5	.
JUDITH	AD_06	19	45	11	.	.	.	.	.	.	23	22	.	.	18	13	.	.	.	.	.	5
JUDITH	AD_07	27	.	.	.	.	27	.	.	.	.	.	.	.	27	24	8	8	12	.	.	.
JUDITH	AD_08	23	26	.	24	21	.	.	.	.	.	.	.	.	23	13	.	.	.	.	.	5
JUDITH	AD_09	17	34	16	23	.	.	.	.	.	.	.	.	.	17	17	8	.	8	.	.	.
JUDITH	AD_10	13	39	13	17	.	.	17	.	.	.	.	.	.	13	12	.	.	8	.	.	6
JUDITH	AD_11	24	.	.	.	.	.	.	.	.	.	.	.	24	10	10	10	.	8	.	.	.

	Med-Risk Legs	Med-Risk Back	Keying	Writing	Staple	Mouse	Mntrng	Calling	Cpying	Drftng	Filing	Calcltr	Lifting	Micro-scope	Score S N	Score HWA	Score Back	Score Legs	Score Head	Gold Std
Subject	IId-4	IId-5	III-1	III-2	III-3	III-4	III-5	III-6	III-7	III-8	III-9	III-10	III-11	III-12						
DENNIS	.	.	1	1	.	.	.	.	.	.	.	.	.	.	4	4	0	0	2	2
DENNIS	.	.	1	1	.	.	.	1	.	.	.	.	.	.	6	2	2	0	3	2
DENNIS	.	.	.	.	.	.	.	.	.	.	.	.	.	1	0	12	0	0	0	3
JUDITH	4	.	1	.	.	1	1	.	.	.	.	.	.	.	13	13	8	4	8	3
JUDITH	4	.	1	1	.	.	.	1	.	.	.	.	.	.	13	17	8	4	9	1
JUDITH	4	4	1	1	.	.	.	.	.	.	.	1	.	.	7	19	4	4	5	2
JUDITH	4	.	1	1	.	.	1	1	.	.	.	.	.	.	12	14	8	4	10	3
JUDITH	.	4	1	.	.	.	1	.	.	1	.	.	.	.	5	19	4	0	10	2
JUDITH	7	6	1	.	.	.	.	.	.	.	1	.	1	.	13	19	8	7	5	2
JUDITH	.	.	.	.	.	.	1	.	.	.	.	.	.	.	24	27	12	8	8	3
JUDITH	4	5	.	.	1	.	.	.	1	.	.	.	.	.	13	23	5	4	5	2
JUDITH	4	.	1	1	.	.	.	.	.	.	.	.	.	.	17	17	8	4	8	2
JUDITH	4	.	1	1	.	.	1	1	.	.	.	.	.	.	12	13	8	4	8	2
JUDITH	.	.	.	.	.	.	.	.	.	.	.	.	.	1	10	24	8	0	10	3

Subject	Scenario	Task	Ques1	Ques2	Ques3	Ques4	Ques5	Ques6	Ques7	Ques8	Ques9	Ques10	Ques11	Ques12	Ques13	Ques14	Ques15	Ques16	Ques17	Ques18	Ques19	Ques20	Ques21	Ques22	Ques23	Ques24	Ques25	Ques26
ALTADAWN	1	1	1	4	0	0	0	0	4	4	4	3	0	0	4	1	0	0	0	0	0	0	0	2	2	2	0	0
ALTADAWN	2	1	1	1	0	0	0	0	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0	1	1	1	0	0
ALTADAWN	2	2	4	4	0	0	0	0	4	4	4	3	0	0	0	4	4	0	0	0	0	0	0	2	2	2	0	0
ALTADAWN	2	5	1	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ALTADAWN	3	2	1	1	0	0	0	0	4	1	1	1	0	0	4	1	0	0	0	4	4	0	0	1	2	0	0	0
ALTADAWN	3	10	1	1	0	0	0	0	4	4	1	3	0	4	4	1	0	0	0	4	4	0	0	1	2	0	0	0
ALTADAWN	4	1	4	4	0	0	0	0	4	4	1	3	0	0	0	0	0	0	0	0	0	0	0	2	2	0	2	0
ALTADAWN	4	2	1	0	0	0	0	0	4	1	4	3	0	0	0	1	1	0	0	0	0	0	0	2	0	0	0	0
ALTADAWN	4	4	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	2	0
ALTADAWN	4	5	1	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ALTADAWN	5	7	4	0	0	0	0	0	0	4	0	3	0	0	0	0	4	0	0	0	0	0	0	2	2	2	2	0
ALTADAWN	6	1	4	4	0	0	0	0	4	4	0	3	0	0	0	0	4	4	0	0	0	4	0	2	0	2	1	0
ALTADAWN	6	8	4	4	0	4	0	0	4	4	4	3	1	0	0	4	1	4	0	0	0	4	4	0	0	2	0	0
ALTADAWN	6	9	0	0	0	4	0	0	4	4	0	0	4	4	0	0	0	4	0	0	0	4	1	0	0	2	0	0
ALTADAWN	7	4	4	4	0	0	0	0	4	1	1	1	0	0	0	1	4	0	0	0	0	0	0	2	2	2	0	0
ALTADAWN	8	2	0	1	0	0	0	0	4	4	4	3	0	0	0	4	0	0	0	4	0	0	0	2	0	2	0	0
ALTADAWN	8	3	0	4	0	0	0	0	4	4	4	3	0	4	1	4	0	0	0	4	0	0	0	2	0	2	0	0
ALTADAWN	9	1	4	1	0	0	0	0	4	1	1	3	0	0	1	0	0	0	0	4	4	0	0	2	2	0	0	0
ALTADAWN	9	2	1	4	0	0	0	0	4	1	4	3	0	1	0	1	1	0	0	4	4	0	0	2	0	2	0	0
ALTADAWN	10	1	4	1	0	0	0	0	4	0	0	3	0	0	0	0	4	0	0	0	0	0	0	1	2	0	0	0
ALTADAWN	10	2	4	4	0	0	0	0	4	0	4	3	0	0	0	4	4	0	0	0	0	0	0	1	2	0	0	0
ALTADAWN	10	5	1	1	0	0	0	1	1	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
ALTADAWN	11	11	4	1	0	0	0	0	0	4	4	1	0	0	0	0	4	0	0	0	0	0	0	2	0	0	0	0
DENNIS	1	1	1	0	0	0	0	0	1	0	0	3	0	1	4	0	1	0	0	0	0	0	0	2	2	1	0	0
DENNIS	2	1	0	1	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	1	0	0
DENNIS	2	2	0	1	0	0	0	0	4	1	4	0	0	0	0	1	0	0	0	0	0	0	0	2	0	1	0	0
DENNIS	2	5	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
DENNIS	3	2	0	1	0	0	0	0	4	0	1	0	0	0	0	1	0	0	0	0	0	0	0	2	2	0	0	0
DENNIS	3	10	0	1	0	0	0	0	4	0	1	3	0	0	1	1	0	0	0	0	0	0	0	2	2	0	0	0
DENNIS	4	1	1	0	0	0	0	0	1	4	0	3	0	1	0	0	0	0	0	0	0	0	0	2	2	0	2	0
DENNIS	4	2	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
DENNIS	4	4	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	2	0
DENNIS	4	5	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DENNIS	5	7	0	0	0	0	0	0	0	1	0	3	0	4	4	0	0	0	0	0	0	0	0	2	2	0	0	0
DENNIS	6	1	1	0	0	0	0	0	1	1	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0
DENNIS	6	8	0	4	0	1	1	0	1	1	1	0	0	0	0	0	0	4	4	0	0	4	1	1	0	1	0	0
DENNIS	6	9	1	1	0	1	1	0	1	1	0	0	0	0	0	0	0	4	4	0	0	1	1	0	0	0	0	0

Subject	Scenario	Task	Ques1	Ques2	Ques3	Ques4	Ques5	Ques6	Ques7	Ques8	Ques9	Ques10	Ques11	Ques12	Ques13	Ques14	Ques15	Ques16	Ques17	Ques18	Ques19	Ques20	Ques21	Ques22	Ques23	Ques24	Ques25	Ques26
DENNIS	7	4	4	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0
DENNIS	8	2	0	0	0	0	0	0	4	1	4	0	0	4	0	4	0	0	0	0	0	0	0	2	0	0	0	0
DENNIS	8	3	0	0	0	0	0	0	4	1	4	0	0	4	0	4	0	0	0	0	0	0	0	2	0	0	0	0
DENNIS	9	1	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0
DENNIS	9	2	0	1	0	1	0	0	4	1	1	1	0	1	0	1	0	0	0	0	0	0	0	2	0	0	0	0
DENNIS	10	1	4	0	0	0	0	0	4	0	0	3	0	1	0	0	4	0	0	0	0	0	0	2	2	0	0	0
DENNIS	10	2	1	1	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	2	0	0	0	0
DENNIS	10	5	1	1	0	0	0	4	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
DENNIS	11	11	0	0	0	0	0	0	0	4	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
GLISSON	1	1	4	1	0	0	0	0	4	1	1	3	0	4	0	0	1	0	0	4	0	0	0	2	2	2	0	0
GLISSON	2	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	1	1	1	0	0
GLISSON	2	2	0	1	0	0	0	0	0	0	4	1	0	0	0	0	1	0	0	4	0	0	0	0	0	2	0	0
GLISSON	2	5	0	1	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	0	0	0	0	1	0	0
GLISSON	3	2	1	1	0	0	0	0	0	0	1	1	0	0	1	1	1	0	0	1	0	0	0	1	1	0	0	0
GLISSON	3	10	1	0	0	0	0	0	0	0	0	3	0	4	4	0	0	0	0	4	0	0	0	2	2	0	0	0
GLISSON	4	1	4	0	0	0	0	0	4	0	0	3	0	4	0	0	0	0	0	4	0	0	0	2	2	0	0	0
GLISSON	4	2	1	0	0	0	0	0	1	0	1	1	0	1	0	0	1	0	0	1	0	0	0	1	0	0	0	0
GLISSON	4	4	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	4	0	0	0	2	2	0	0	0
GLISSON	4	5	4	0	0	0	0	0	4	0	0	3	1	0	0	0	0	0	0	4	0	0	0	2	0	0	0	0
GLISSON	5	7	0	1	0	0	0	0	0	4	0	3	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0
GLISSON	6	1	1	0	0	0	0	0	1	1	0	1	0	1	0	0	1	4	0	0	0	0	0	1	1	1	0	0
GLISSON	6	8	4	4	0	4	1	0	1	1	0	0	0	0	0	4	1	4	4	0	0	4	1	2	2	2	0	0
GLISSON	6	9	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	4	0	0	1	1	0	0	1	0	0
GLISSON	7	4	0	1	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	4	0	0	0	2	2	2	1	0
GLISSON	8	2	1	1	0	0	0	0	0	1	1	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0
GLISSON	8	3	1	1	0	0	0	0	0	1	1	1	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0
GLISSON	9	1	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	1	1	0	0	0
GLISSON	9	2	0	1	0	1	1	0	0	0	1	3	0	1	0	0	1	0	0	1	0	0	0	2	2	0	0	0
GLISSON	10	1	0	1	0	0	0	0	1	1	0	3	0	4	0	0	4	0	0	0	0	0	0	2	2	0	0	0
GLISSON	10	2	0	1	0	0	0	0	1	0	1	0	0	1	0	0	1	4	0	0	0	0	0	1	0	0	0	0
GLISSON	10	5	0	1	0	0	0	1	1	1	0	1	1	1	0	0	1	0	0	0	0	0	0	1	1	0	0	0
GLISSON	11	11	0	0	0	0	0	0	4	4	0	3	4	0	4	0	4	0	0	4	0	0	0	2	2	2	0	2
JENNIFER	1	1	0	0	0	0	0	0	4	0	0	3	0	0	4	0	4	0	0	0	0	0	0	2	1	0	0	2
JENNIFER	2	1	1	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0
JENNIFER	2	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JENNIFER	2	5	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JENNIFER	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Subject	Scenario	Task	Ques1	Ques2	Ques3	Ques4	Ques5	Ques6	Ques7	Ques8	Ques9	Ques10	Ques11	Ques12	Ques13	Ques14	Ques15	Ques16	Ques17	Ques18	Ques19	Ques20	Ques21	Ques22	Ques23	Ques24	Ques25	Ques26
JENNIFER	3	10	0	0	0	0	0	0	1	0	0	3	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
JENNIFER	4	1	4	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	1	2	0	1	0
JENNIFER	4	2	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JENNIFER	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	2
JENNIFER	4	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JENNIFER	5	7	0	0	0	0	0	0	0	4	0	0	0	0	4	0	0	0	0	0	0	0	0	2	2	0	0	0
JENNIFER	6	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	4	0	0	0	0	0	0	1	1	1	0
JENNIFER	6	8	0	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0	0	1	0	0
JENNIFER	6	9	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	4	0	0	4	0	0	0	0	0	0
JENNIFER	7	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	2	2	0	0
JENNIFER	8	2	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	1	0	0
JENNIFER	8	3	0	0	0	4	0	0	0	0	4	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JENNIFER	9	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
JENNIFER	9	2	0	0	0	1	0	0	4	0	1	0	0	1	0	1	4	0	0	4	0	0	0	0	0	0	0	0
JENNIFER	10	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	4	0	0	4	0	0	0	1	2	0	0	0
JENNIFER	10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
JENNIFER	10	5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
JENNIFER	11	11	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
JOE	1	1	4	4	0	0	0	0	4	0	0	3	0	0	0	0	4	0	0	4	0	0	0	2	2	2	0	2
JOE	2	1	0	1	0	0	0	0	4	0	0	3	0	0	0	0	0	0	0	0	0	0	0	2	2	2	0	0
JOE	2	2	0	4	0	0	0	0	4	0	1	3	0	0	0	0	4	0	0	0	0	0	0	2	2	2	0	0
JOE	2	5	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	2	2	2	0	0
JOE	3	2	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	4	0	0	0	2	2	0	0	0
JOE	3	10	0	4	0	0	0	0	4	0	0	3	0	4	4	0	0	0	0	4	0	0	0	2	2	0	0	0
JOE	4	1	0	4	0	0	0	0	4	0	0	3	0	0	4	0	0	0	0	4	0	0	0	2	2	0	0	0
JOE	4	2	0	1	0	0	0	0	4	0	0	3	0	0	4	0	4	0	0	4	0	0	0	2	2	0	0	0
JOE	4	4	1	0	0	0	0	0	4	0	0	0	0	0	4	0	0	0	0	4	0	0	0	2	2	0	0	0
JOE	4	5	0	0	0	0	0	0	4	0	0	0	0	0	1	0	0	0	0	4	0	0	0	2	2	0	0	0
JOE	5	7	0	0	0	0	0	0	0	0	0	3	0	0	4	0	0	0	0	0	0	0	0	2	2	2	0	0
JOE	6	1	4	4	0	4	1	0	4	0	0	3	4	4	0	0	1	4	0	4	0	4	0	1	2	2	0	0
JOE	6	8	0	4	0	4	1	0	4	1	4	3	4	4	0	0	0	4	4	4	0	4	4	1	0	2	0	0
JOE	6	9	1	4	0	4	1	0	0	0	1	1	0	4	0	0	0	4	4	4	0	4	1	0	0	0	0	0
JOE	7	4	1	4	0	0	0	0	0	0	0	3	1	1	0	0	1	0	0	4	1	0	0	2	2	2	0	0
JOE	8	2	0	0	0	0	0	0	4	0	4	3	0	0	0	0	0	0	0	4	4	0	0	2	2	2	0	0
JOE	8	3	0	0	0	0	0	0	4	0	4	3	0	0	0	0	0	0	0	0	4	0	0	2	0	0	0	0
JOE	9	1	0	1	0	0	0	0	4	0	1	0	0	1	0	0	0	0	0	4	0	0	0	2	2	0	0	0
JOE	9	2	0	1	0	0	0	0	4	0	1	0	0	1	0	0	4	0	0	4	0	0	0	2	2	0	0	0

Subject	Scenario	Task	Ques1	Ques2	Ques3	Ques4	Ques5	Ques6	Ques7	Ques8	Ques9	Ques10	Ques11	Ques12	Ques13	Ques14	Ques15	Ques16	Ques17	Ques18	Ques19	Ques20	Ques21	Ques22	Ques23	Ques24	Ques25	Ques26
JOE	10	1	4	1	0	0	0	1	1	0	0	3	0	0	0	0	4	0	0	0	0	0	0	2	2	0	0	0
JOE	10	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	4	0	0	0	0	0	0	1	1	0	0	0
JOE	10	5	1	0	0	0	0	4	4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	2	2	0	0	0
JOE	11	11	0	0	0	0	0	0	0	0	4	1	3	0	0	4	0	4	0	0	0	0	0	2	0	2	0	0
JUDITH	1	1	4	4	1	0	0	0	4	4	4	3	0	0	4	0	4	0	0	4	4	0	0	2	2	2	0	2
JUDITH	2	1	4	0	4	0	0	0	4	4	4	3	0	1	4	0	4	0	0	4	4	0	0	2	2	2	2	2
JUDITH	2	2	4	4	1	1	0	0	4	1	4	3	0	1	4	4	4	0	0	4	4	0	0	2	2	2	0	2
JUDITH	2	5	4	4	1	1	0	0	4	1	4	3	1	1	4	4	4	0	0	4	4	0	0	2	2	2	0	2
JUDITH	3	2	0	0	0	0	0	0	4	4	4	1	0	1	4	0	0	0	0	4	4	0	0	2	2	0	0	1
JUDITH	3	10	4	1	0	0	0	0	4	4	4	3	4	4	4	1	0	0	0	4	4	0	0	2	2	0	0	1
JUDITH	4	1	4	4	0	0	0	0	4	4	4	3	0	1	4	0	4	0	0	4	4	0	0	2	2	2	2	2
JUDITH	4	2	4	4	0	0	0	0	4	1	4	3	0	4	4	1	4	0	0	4	4	0	0	2	2	2	2	2
JUDITH	4	4	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	4	4	0	0	2	2	2	2	2
JUDITH	4	5	4	4	4	0	0	4	4	4	4	1	4	4	0	4	4	0	0	4	4	0	0	2	2	2	2	2
JUDITH	5	7	1	4	0	0	0	0	0	4	4	3	4	0	4	0	4	0	0	0	0	0	0	2	2	2	2	2
JUDITH	6	1	1	1	0	0	0	0	4	4	4	3	0	0	0	0	1	4	0	1	0	4	0	1	2	2	2	2
JUDITH	6	8	4	4	0	4	4	0	4	4	4	3	4	4	1	4	1	4	4	0	0	4	4	0	0	2	0	1
JUDITH	6	9	1	1	0	4	4	0	4	4	4	1	4	4	1	4	1	4	4	0	0	4	4	0	0	2	0	0
JUDITH	7	4	4	4	4	4	0	4	4	4	4	3	4	4	4	4	4	4	0	4	4	4	0	2	2	2	2	2
JUDITH	8	2	4	4	0	4	0	0	1	4	4	3	4	4	1	4	1	0	0	4	4	0	0	2	0	2	0	2
JUDITH	8	3	4	4	0	4	0	0	1	4	4	3	4	4	1	1	1	0	0	4	4	0	0	2	0	2	0	0
JUDITH	9	1	4	4	4	0	0	0	4	1	4	0	0	0	4	1	4	0	0	4	4	0	0	2	2	2	2	1
JUDITH	9	2	4	4	4	1	0	1	4	4	4	3	0	4	4	4	4	0	0	4	4	0	0	2	2	2	1	0
JUDITH	10	1	0	4	1	0	0	0	4	0	4	3	1	0	4	1	4	0	0	4	4	0	0	2	2	2	2	2
JUDITH	10	2	0	4	1	0	0	0	4	1	4	3	1	0	4	4	4	0	0	4	4	0	0	2	2	2	2	2
JUDITH	10	5	4	4	4	0	0	4	1	1	1	0	4	1	1	1	4	0	0	4	4	0	0	0	1	2	1	1
JUDITH	11	11	4	1	1	0	0	0	4	4	4	3	1	4	4	4	4	0	0	4	0	0	0	2	2	2	2	2
KAREN	1	1	0	1	0	0	0	1	4	4	1	3	0	1	4	0	0	0	0	0	0	0	0	1	2	2	0	2
KAREN	2	1	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
KAREN	2	2	0	1	0	0	0	0	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0
KAREN	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
KAREN	3	2	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	1	0	0	0	1	1	0	0	0
KAREN	3	10	0	0	0	0	0	0	4	0	0	3	0	4	4	0	0	0	0	4	0	0	0	2	2	0	0	0
KAREN	4	1	1	1	0	0	0	0	4	4	0	3	0	0	0	0	0	0	0	0	4	0	0	2	2	0	0	0
KAREN	4	2	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0
KAREN	4	4	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	4	0	0	2	2	0	0	0
KAREN	4	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	1	2	0	0	0

Subject	Scenario	Task	Ques1	Ques2	Ques3	Ques4	Ques5	Ques6	Ques7	Ques8	Ques9	Ques10	Ques11	Ques12	Ques13	Ques14	Ques15	Ques16	Ques17	Ques18	Ques19	Ques20	Ques21	Ques22	Ques23	Ques24	Ques25	Ques26
KAREN	5	7	0	0	0	0	0	0	1	4	0	3	0	4	4	0	0	0	0	0	0	0	0	2	2	2	0	0
KAREN	6	1	1	1	0	0	0	0	1	1	0	1	0	0	0	0	1	4	0	0	0	0	0	0	0	1	0	0
KAREN	6	8	0	4	0	4	0	0	4	4	4	1	0	4	0	0	1	4	4	0	0	0	4	0	0	2	0	0
KAREN	6	9	0	1	0	1	1	0	0	1	1	0	0	1	0	0	0	0	4	0	0	0	0	0	0	0	0	0
KAREN	7	4	0	4	0	0	0	0	1	1	0	0	1	1	0	0	1	0	0	0	0	0	0	2	2	2	0	2
KAREN	8	2	0	0	0	1	0	0	1	1	1	0	0	1	0	1	0	0	0	1	0	0	0	0	0	1	0	0
KAREN	8	3	0	0	0	1	0	0	0	1	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
KAREN	9	1	1	1	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0	1	0	0	0	1	1	1	0	0
KAREN	9	2	4	4	0	1	0	0	4	1	4	3	0	1	0	4	0	0	0	4	0	0	0	1	0	2	0	0
KAREN	10	1	0	1	0	0	0	0	1	0	0	0	0	0	4	0	4	0	0	1	0	0	0	2	1	0	0	0
KAREN	10	2	0	1	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	1	0	0	0	1	1	0	0	0
KAREN	10	5	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
KAREN	11	11	0	0	0	0	0	0	0	4	4	3	0	0	4	0	1	0	0	0	0	0	0	0	0	2	0	1
PAT	1	1	0	1	0	0	0	0	1	4	0	3	0	0	4	0	4	0	0	4	4	0	0	2	2	2	2	2
PAT	2	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1	0	0	1	1	0	0	1	1	1	1	0
PAT	2	2	4	4	0	0	0	0	4	0	4	3	0	4	0	4	4	0	0	4	4	0	0	2	0	2	0	0
PAT	2	5	0	0	0	0	0	0	1	0	1	1	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0
PAT	3	2	0	0	0	0	0	0	4	0	0	0	0	0	4	0	0	0	0	4	4	0	0	2	2	0	2	1
PAT	3	10	0	0	0	0	0	0	4	0	0	3	0	4	4	0	0	0	0	4	4	0	0	2	2	0	0	0
PAT	4	1	0	0	0	0	0	0	4	1	0	0	0	0	0	0	4	0	0	0	4	0	0	2	2	0	0	0
PAT	4	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	4	0	0	0	0	0	0	0
PAT	4	4	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	4	0	0	2	2	0	0	0
PAT	4	5	0	0	0	0	0	0	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PAT	5	7	1	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	0	0
PAT	6	1	0	1	0	0	0	0	0	1	0	1	0	0	1	0	1	4	0	1	0	1	0	1	1	0	1	1
PAT	6	8	4	4	0	4	1	0	4	4	4	3	0	4	0	4	0	4	4	0	0	4	4	0	0	1	0	0
PAT	6	9	0	0	0	1	1	0	0	1	1	1	0	1	0	0	1	0	4	0	0	1	0	0	0	0	0	0
PAT	7	4	1	1	0	0	0	0	0	1	1	0	0	0	1	0	1	0	0	1	1	1	0	2	2	2	2	0
PAT	8	2	0	0	0	1	0	0	1	0	1	1	0	1	0	1	1	0	0	1	1	0	0	1	0	1	0	0
PAT	8	3	0	0	0	1	0	0	1	1	1	1	0	1	0	1	1	0	0	1	1	0	0	1	0	1	0	0
PAT	9	1	1	1	1	0	0	0	1	1	0	1	0	0	0	0	1	0	0	1	1	0	0	1	1	0	0	0
PAT	9	2	4	4	4	4	0	0	1	1	4	3	1	4	0	1	4	0	0	0	4	0	0	0	0	0	0	0
PAT	10	1	0	4	0	0	0	1	4	1	4	3	0	0	0	0	4	0	0	0	0	0	0	1	2	0	0	0
PAT	10	2	4	1	0	0	0	0	1	4	4	3	0	1	0	1	4	0	0	0	0	0	0	2	2	0	0	0
PAT	10	5	1	1	0	0	0	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
PAT	11	11	1	0	0	0	0	0	4	4	4	3	0	0	4	0	4	0	0	0	1	0	0	2	2	0	0	0
WILLIAM	1	1	0	0	0	0	0	0	0	4	0	3	0	0	4	0	1	0	0	0	0	0	0	0	2	1	0	1

Subject	Scenario	Task	Ques1	Ques2	Ques3	Ques4	Ques5	Ques6	Ques7	Ques8	Ques9	Ques10	Ques11	Ques12	Ques13	Ques14	Ques15	Ques16	Ques17	Ques18	Ques19	Ques20	Ques21	Ques22	Ques23	Ques24	Ques25	Ques26
WILLIAM	2	1	0	0	0	0	0	0	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
WILLIAM	2	2	0	4	0	0	0	0	0	0	4	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
WILLIAM	2	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WILLIAM	3	2	0	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0
WILLIAM	3	10	0	1	0	0	0	0	4	0	1	3	0	0	4	0	0	0	0	4	0	0	0	0	2	0	0	0
WILLIAM	4	1	0	0	0	0	0	0	4	0	0	3	0	0	0	0	0	0	0	0	0	0	0	1	2	0	2	0
WILLIAM	4	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WILLIAM	4	4	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	2	0
WILLIAM	4	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WILLIAM	5	7	4	0	0	0	0	0	0	4	0	1	0	0	0	0	0	0	0	0	0	0	0	2	2	0	2	0
WILLIAM	6	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	1	4	0	0	0	1	0	0	1	1	1	0
WILLIAM	6	8	4	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0	0	2	0	0
WILLIAM	6	9	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0
WILLIAM	7	4	0	1	0	0	0	0	1	0	0	0	1	0	0	0	4	0	0	0	0	0	0	2	2	2	0	2
WILLIAM	8	2	0	4	0	0	0	0	0	4	4	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
WILLIAM	8	3	0	4	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WILLIAM	9	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	4	0	0	0	0	2	0	0	0
WILLIAM	9	2	0	4	0	1	0	0	0	1	4	0	0	1	0	1	0	0	0	4	0	0	0	0	0	0	0	0
WILLIAM	10	1	4	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
WILLIAM	10	2	0	0	0	0	0	0	1	0	1	blank	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
WILLIAM	10	5	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WILLIAM	11	11	0	0	0	0	0	0	0	4	0	3	0	0	4	0	0	0	0	0	0	0	0	0	0	1	0	0
X	1	1	0	0	0	0	0	0	4	1	0	0	0	0	0	1	0	0	0	0	0	0	0	2	2	2	0	2
X	2	1	0	0	0	0	0	0	1	0	0	3	0	0	4	0	1	0	0	0	1	0	0	2	2	2	0	0
X	2	2	0	1	0	0	0	0	0	1	4	0	0	0	1	0	4	0	0	0	1	0	0	2	0	2	0	0
X	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0
X	3	2	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0
X	3	10	0	1	0	0	0	0	1	1	0	3	0	4	4	0	0	0	0	4	0	0	0	1	1	0	0	0
X	4	1	0	0	0	0	0	0	4	1	0	0	0	0	1	0	1	0	0	4	0	0	0	2	2	0	2	0
X	4	2																										
X	4	4	0	0	0	0	0	0	4	1	0	0	0	0	1	0	1	0	0	4	0	0	0	2	2	0	2	0
X	4	5	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
X	5	7	0	0	0	0	0	1	0	1	1	3	4	0	0	0	0	0	0	0	0	0	0	2	2	2	0	2
X	6	1	1	1	0	0	0	0	1	0	1	1	0	1	1	0	1	0	0	0	0	1	1	1	1	1	0	1
X	6	8																										
X	6	9	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	4	0	0	0	1	1	0	0	1	0	1
X	7	4	4	1	0	0	0	0	1	0	0	3	0	0	1	0	1	0	0	1	0	0	0	2	2	2	1	2

Subject	Scenario	Task	Ques1	Ques2	Ques3	Ques4	Ques5	Ques6	Ques7	Ques8	Ques9	Ques10	Ques11	Ques12	Ques13	Ques14	Ques15	Ques16	Ques17	Ques18	Ques19	Ques20	Ques21	Ques22	Ques23	Ques24	Ques25	Ques26
X	8	2	0	0	0	0	0	1	1	0	1	0	0	1	1	1	1	0	0	0	0	0	0	1	0	0	0	0
X	8	3	0	0	0	4	0	1	1	0	4	0	0	4	1	4	1	0	0	0	0	0	0	1	0	0	0	0
X	9	1	1	1	0	1	0	1	1	1	1	0	0	0	1	1	1	0	0	1	0	0	0	1	1	1	0	1
X	9	2	4	4	0	4	0	1	1	1	4	0	0	0	1	4	1	0	0	4	0	0	0	1	1	2	0	1
X	10	1	0	1	0	0	0	0	0	0	0	3	0	0	4	0	0	0	0	0	1	0	0	2	2	0	0	0
X	10	2	0	1	0	0	0	0	0	0	1	1	0	0	1	1	0	0	0	0	1	0	0	1	1	0	0	0
X	10	5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
X	11	11	0	0	1	0	0	0	4	1	4	0	0	0	0	0	4	0	0	0	0	0	0	0	0	2	0	0

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SUBJECT	SCENARIO	TASK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Paul	1	1	4	4	0	0	0	0	4	4	0	0	0	0	4		0	4	0	0	4	0	0	0	2	2	2	2	0
Dan	1	1	1	1	0	0	0	0	4	4	1	4	1	0	4		1	1	0	0	4	4	0	0	2	4	4	0	0
M. Ward	1	1	4	4	1	0	0	0	4	4	0	3	0	0	4		0	4	0	0	4	0	0	0	2	2	2	0	0
Andy	1	1	4	1	0	0	0	0	4	4	1	3	0	0	4		0	4	0	0	4	4	0	0	2	2	0	0	1
Van	1	1	1	0	0	0	0	0	4	4	0	3	0	0	4		0	1	0	0	4	4	0	0	2	2	2	0	2
Concensus	1	1	4	1	0	0	0	0	4	4	0	3	0	0	4		0		0	0	4	4	0	0	2	2	2	0	0
Paul	2	1	0	1	0	0	0	0	1	1	4	3	0	0	0		0	1	0	0	1	0	0	0	1	1	1	1	0
Dan	2	1	1	0	0	0	0	0	1	0	0	1	0	0	0		0	0	0	0	0	0	0	0	0	1	0	0	0
M. Ward	2	1	1	1	0	0	0	0	0	1	1	0	0	0	1		0	1	0	0	0	0	0	0	2	1	0	0	0
Andy	2	1	0	1	0	0	0	0	1	1	1	1	0	0	0		0	0	0	0	0	0	0	0	1	1	1	0	1
Van	2	1	1	0	0	0	0	0	1	0	0	0	0	0	0		0	0	0	0	0	0	0	0	1	1	0	0	0
Concensus	2	1	1	0	0	0	0	0	1			1	0	0	0		0	0	0	0	0	0	0	0	1	1	0	0	0
Paul	2	2	0	0	0	0	0	0	4	0	0	0	0	0	0		0	4	0	0	4	0	0	0	2	0	0	0	0
Dan	2	2	1	0	0	0	0	0	0	0	1	0	0	0	4		0	1	1	0	0	0	0	0	1	0	0	0	0
M. Ward	2	2	0	4	0	0	0	0	0	4	4	3	0	0	0		4	4	0	0	0	0	0	0	2	0	0	0	0
Andy	2	2	0	1	0	0	0	0	4	0	1	0	0	0	4		0	1	0	0	0	0	0	0	2	0	2	0	1
Van	2	2	0	1	0	0	0	0	1	0	0	0	0	0	0		0	1	0	0	0	0	0	0	1	0	0	0	0
Concensus	2	2	0	1	0	0	0	0	1	0	1	0	0	0	0		0	1	0	0	0	0	0	0		0	0	0	0
Paul	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
Dan	2	5	1	1	0	0	0	0	0	0	0	0	0	0	1		0	1	0	0	0	0	0	0	0	0	0	0	0
M. Ward	2	5	1	1	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
Andy	2	5	0	1	0	0	0	0	0	0	0	0	0	0	0		0	0	1	0	0	0	0	0	0	0	0	0	0
Van	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
Concensus																													
Paul	3	10	0	0	0	0	0	0	4	0	0	3	0	4	4		0	0	0	0	4	4	0	0	0	0	0	0	0
Dan	3	10	4	4	0	0	0	0	1	0	0	4	0	1	4		1	1	0	0	4	0	0	0	0	0	0	0	0
M. Ward	3	10	0	0	0	0	0	0	4	4	4	3	0	4	4		0	0	0	0	0	0	0	0	0	0	0	0	0
Andy	3	10	0	1	0	0	0	0	4	4	1	3	0	4	4		0	0	0	0	4	2	0	0	2	2	0	0	0
Van	3	10	0	1	1	0	0	0	1	1	0	4	0	4	1		0	0	0	0	4	0	0	0	0	2	0	0	0
Concensus																													
Paul?																													
Dan	3	2	0	0	0	0	0	0	4	0	1	0	0	0	4		1	1	0	0	4	0	0	0	1	1	0	0	0
M. Ward	3	2	did n	fill out																									
Andy	3	2	0	1	0	0	0	0	4	1	0	0	0	0	4		0	0	0	0	4	2	0	0	2	2	0	0	0

SUBJECT	SCENARIO	TASK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Van	3	2	1	0	0	0	0	0	1	0	1	0	0	0	0		1	0	0	0	1	0	0	0	1	1	0	0	0
Concensus																													
Paul	4	4	0	0	0	0	0	0	4	0	0	0	0	0	0		0	4	0	0	4	0	0	0	2	2	2	0	2
Dan	4	4	0	0	0	0	0	0	4	0	0	0	0	0	0		0	0	0	0	0	1	0	0	4	4	0	0	0
M. Ward	4	4	0	1	0	0	0	0	4	0	0	3	0	0	4		0	4	0	0	4	0	0	0	2	2	0	2	0
Andy	4	4	1	1	0	0	0	0	0	1	0	1	0	0	0		0	0	0	0	0	4	0	0	2	2	0	0	0
Van	4	4	0	0	0	0	0	0	4	0	0	0	0	0	0		0	0	0	0	4	4	0	0	0	4	0	0	0
Concensus	4	4	0		0	0	0	0	4	0	0		0	0	0		0		0	0			0	0			0	0	0
Paul	4	1	0	4	0	0	0	0	0	4	0	3	0	0	4		0	0	0	0	0	0	0	0	0	0	0	0	0
Dan	4	1	1	0	0	0	0	0	1	0	0	1	0	0	0		0	0	0	0	0	1	0	0	2	4	0	0	0
M. Ward	4	1	4	1	0	0	0	0	4	4	0	3	0	0	4		0	4	0	0	4	0	0	0	2	2	0	2	0
Andy	4	1	4	0	0	0	0	0	0	4	0	1	0	0	0		4	0	0	0	4	0	0	0	0	2	0	0	0
Van	4	1	1	0	0	0	0	0	4	1	0	1	0	0	0		0	4	0	0	4	4	0	0	2	2	0	0	0
Concensus	4	1			0	0	0	0			0		0	0					0	0			0	0			0	0	0
Paul	4	5	0	0	0	0	0	4	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
Dan	4	5	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	1	0	0	0	0	0	0	0
M. Ward	4	5	0	0	0	0	0	0	4	0	0	0	0	0	4		0	1	0	0	4	0	0	0	0	0	0	0	0
Andy	4	5	0	1	0	0	0	0	1	0	0	0	0	0	0		0	4	0	0	0	4	0	0	0	0	0	0	0
Van	4	5	0	0	0	0	0	0	0	0	0	0	0	0	0		0	4	0	0	4	4	0	0	0	4	0	0	0
Concensus	4	5	0	0	0	0	0			0	0	0	0	0			0		0	0			0	0	0		0	0	0
Paul	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
Dan	4	2	0	0	0	0	0	0	4	0	0	0	0	0	0		0	1	0	0	0	1	0	0	0	0	0	0	0
M. Ward	4	2	0	0	0	0	0	0	4	1	1	1	0	1	1		0	1	0	0	1	0	0	0	1	0	0	0	0
Andy	4	2	0	0	0	0	0	0	1	0	0	0	0	1	1		0	1	0	0	0	1	0	0	2	0	0	0	0
Van	4	2	0	0	0	0	0	0	1	0	0	1	0	0	0		0	4	0	0	1	1	0	0	1	1	0	0	0
Concensus	4	2	0	0	0	0	0	0		0	0		0				0		0	0			0	0		0	0	0	0
Paul	5	7	4	1	0	0	0	0	4	4	4	3	0	0	4		0	0	0	0	0	0	0	0	2	2	2	2	0
Dan	5	7	0	0	0	0	0	0	0	1	1	1	0	0	0		0	0	0	0	0	0	0	0	2	2	0	0	0
M. Ward	5	7	0	0	0	0	0	0	0	4	0	3	0	1	0		0	0	0	0	0	0	0	0	2	2	2	0	0
Andy	5	7	0	0	0	0	0	0	0	4	0	3	0	0	4		0	0	0	0	0	0	0	0	2	2	0	0	0
Van	5	7	0	0	0	0	0	0	1	4	1	1	0	0	4		0	0	0	0	0	0	0	0	2	2	0	0	0
Concensus	5	7		0	0	0	0	0					0	0			0	0	0	0	0	0	0	0	2	2		0	0
Paul	6	1	1	1	0	0	0	0	1	1	1	1	1	0	1		0	1	4	0	1	0	1	0	1	1	1	1	1

SUBJECT	SCENARIO	TASK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Dan	6	1	0	4	0	0	0	0	4	4	0	1	0	0	0		0	0	4	0	0	0	4	0	0	0	0	0	0
M. Ward	6	1	did n	fill out																									
Andy	6	1	0	4	0	0	0	0	4	4	0	1	0	0	4		0	4	0	0	0	0	4	0	1	2	2	2	2
Van	6	1	0	0	0	0	0	0	1	1	0	1	0	0	0		0	1	0	0	1	0	0	0	0	1	1	0	1
Concensus	6	1			0	0	0	0			0	1	0	0			0			0		0		0					
Paul	6	8	4	4	0	4	4	0	1	4	4	0	0	4	0		0	1	4	4	0	0	4	1	0	0	2	0	2
Dan	6	8	1	1	0	4	1	0	0	0	1	1	1	0	0		1	1	4	4	0	0	4	1	0	0	1	0	0
M. Ward	6	8	4	4	0	1	4	0	1	4	4	1	1	1	0		0	1	4	4	0	0	4	4	0	0	2	0	0
Andy	6	8	4	4	0	4	1	0	4	1	4	3	0	4	0		0	0	4	0	0	0	4	1	0	0	2	0	0
Van	6	8	1	4	1	1	4	0	1	0	1	3	1	4	1		0	0	4	4	0	0	4	1	0	0	2	0	0
Concensus	6	8			0			0							0		0		4		0	0	4		0	0	2	0	0
Paul	6	9	1	1	0	1	1	0	0	0	0	0	0	1	0		0	1	4	4	0	0	1	1	0	0	0	0	0
Dan	6	9	0	0	0	1	4	0	0	0	0	0	0	0	0		0	1	4	4	0	0	4	1	0	0	1	0	0
M. Ward	6	9	did n	fill out																									
Andy	6	9	0	1	0	1	1	0	0	0	0	0	0	0	0		0	0	4	4	0	0	1	1	0	0	0	0	0
Van	6	9	0	0	0	1	1	0	0	0	0	0	0	1	0		0	0	0	0	0	0	1	0	0	0	0	0	0
Concensus	6	9	0		0	1		0	0	0	0	0	0		0		0				0	0			0	0		0	0
Paul	7	4	4	4	0	0	0	0	4	4	4	3	4	0	0		0	4	0	0	4	0	0	0	2	2	2	2	2
Dan	7	4	1	1	0	0	0	0	1	0	0	1	0	0	0		0	1	0	0	0	0	0	0	2	2	2	0	0
M. Ward	7	4	4	4	1	0	0	0	4	4	1	3	4	0	0		0	4	0	0	0	4	0	0	2	2	2	2	2
Andy	7	4	4	4	0	0	0	0	4	1	0	1	0	1	0		0	4	0	0	0	0	0	0	2	2	2	2	2
Van	7	4	1	4	0	0	0	0	1	0	0	0	0	0	0		0	1	0	0	0	0	0	0	2	2	2	0	2
Concensus	7	4				0	0	0						0	0		0		0	0			0	0	2	2	2		2
Paul	8	3	0	0	0	0	0	0	1	1	1	1	1	1	0		0	1	0	0	0	1	0	0	0	0	1	0	0
Dan	8	3	1	1	0	0	0	0	1	0	1	0	1	1	0		1	0	0	0	0	0	0	0	0	0	0	0	0
M. Ward	8	3	4	4	1	4	0	0	4	4	4	3	1	4	1		4	4	0	0	0	4	0	0	1	0	2	0	0
Andy	8	3	0	0	0	0	0	0	1	1	1	0	0	1	0		1	1	0	0	0	0	0	0	0	0	0	0	0
Van	8	3	0	0	0	0	0	0	1	0	1	1	0	1	0		1	1	0	0	0	0	0	0	0	0	1	0	1
Concensus	8	3					0	0											0	0	0		0	0	0	0		0	0
Paul	8	2	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	1	0	0	0	0	0	1	0	1
Dan	8	2	1	0	0	0	0	0	1	0	1	0	0	0	0		1	0	0	0	0	0	0	0	0	0	0	0	0
M. Ward	8	2	did n	fill out																									
Andy	8	2	0	0	0	0	0	0	1	1	1	0	0	1	0		1	1	0	0	0	0	0	0	0	0	0	0	0
Van	8	2	0	0	0	0	0	0	1	0	1	1	0	1	0		1	1	0	0	0	0	0	0	0	0	0	0	0

SUBJECT	SCENARIO	TASK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Concensus	8	2		0	0	0	0	0					0		0				0	0		0	0	0	0	0		0	
Paul	9	1	0	1	0	0	0	0	1	1	1	1	0	0	0		0	1	0	0	1	0	0	0	1	1	1	0	0
Dan	9	1	1	1	0	0	0	0	4	0	0	1	0	0	0		0	0	0	0	1	0	0	0	2	2	0	0	0
M. Ward	9	1	1	1	0	0	0	0	1	0	1	1	0	0	1		0	1	0	0	0	0	0	0	1	2	0	0	0
Andy	9	1	0	1	0	0	0	0	1	1	0	1	1	0	1		0	0	0	0	0	0	0	0	1	1	0	1	0
Van	9	1	0	1	1	0	0	0	1	0	0	1	0	0	0		0	0	0	0	0	0	0	0	1	1	0	0	0
Concensus	9	1			0	0	0	0				1		0			0		0	0		0	0	0			0	0	0
Paul	9	2	0	0	0	0	0	0	4	0	4	3	0	4	0		0	4	0	0	4	0	0	0	2	0	0	0	0
Dan	9	2	0	1	0	0	0	0	1	0	1	0	0	0	1		1	0	0	0	1	0	0	0	2	0	0	0	0
M. Ward	9	2	4	4	4	0	0	4	4	4	3	0	0	1	1		4	1	0	0	0	0	0	0	2	0	0	0	1
Andy	9	2	4	1	4	0	0	0	4	1	4	0	0	4	0		1	4	0	0	0	0	0	0	2	0	0	0	0
Van	9	2	0	1	0	1	0	0	4	0	1	1	0	1	0		1	4	0	0	0	0	0	0	1	0	0	0	0
Concensus	9	2				0	0						0						0	0		0	0	0	2	0	0	0	0
Paul	10	1	4	0	0	0	0	4	4	0	0	3	0	0	4		0	4	4	0	4	0	0	0	2	2	2	0	0
Dan	10	1	0	0	0	0	0	0	4	0	0	1	0	0	0		0	1	0	0	0	0	0	0	2	4	0	0	0
M. Ward	10	1	0	4	0	0	0	1	4	1	4	3	0	0	4		0	4	0	0	0	4	0	0	2	1	0	2	0
Andy	10	1	4	1	0	0	0	1	4	1	0	3	0	0	4		0	4	0	0	0	0	0	0	2	2	0	2	0
Van	10	1	0	0	0	0	0	0	4	0	0	1	0	0	0		0	4	0	0	0	0	0	0	1	2	0	0	0
Concensus	10	1			0	0	0		4				0	0			0			0			0	0	2				0
Paul	10	2	4	0	0	0	0	0	4	0	0	0	0	0	4		0	4	4	0	1	0	0	0	2	0	0	0	0
Dan	10	2	1	1	0	0	0	0	0	0	1	0	0	0	0		0	0	0	0	0	0	0	0	1	0	0	0	0
M. Ward	10	2	0	4	0	0	0	0	4	1	4	3	0	0	4		0	4	0	0	0	4	0	0	2	0	0	0	0
Andy	10	2	0	1	0	0	0	0	4	1	0	0	0	0	1		0	4	0	0	0	0	0	0	1	0	0	0	0
Van	10	2	0	0	0	0	0	0	1	0	0	0	0	0	0		0	4	0	0	0	0	0	0	0	0	0	0	0
Concensus	10	2			0	0	0	0					0	0			0			0	0		0	0		0	0	0	0
Paul	10	5	1	0	1	0	0	1	1	0	0	0	0	0	0		0	0	0	0	1	0	0	0	0	0	0	0	0
Dan	10	5	0	0	0	0	0	4	1	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
M. Ward	10	5	0	1	0	0	0	1	1	0	1	0	0	0	1		0	4	0	0	0	1	0	0	0	0	0	0	0
Andy	10	5	1	1	0	0	0	1	1	0	0	0	0	0	0		0	1	0	0	0	0	0	0	0	0	0	0	0
Van	10	5	0	1	0	0	0	1	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
Concensus	10	5				0	0		1	0		0	0	0			0		0	0			0	0	0	0	0	0	0
Paul	11	11	4	0	0	0	0	0	4	4	4	3	0	0	4		0	4	4	0	0	0	0	0	2	0	0	0	2
Dan	11	11	0	0	0	0	0	0	4	0	1	4	0	0	4		0	0	0	0	0	0	0	0	2	0	0	0	0

SUBJECT	SCENARIO	TASK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
M. Ward	11	11	4	4	0	0	0	0	0	4	4	3	4	4	4		0	4	0	0	0	0	0	0	2	2	2	0	0
Andy	11	11	0	4	0	0	0	0	4	4	1	3	0	0	4		0	4	0	0	0	0	0	0	2	0	0	0	0
Van	11	11	0	0	0	0	0	0	0	4	0	4	0	0	4		0	4	0	0	0	0	0	0	2	0	0	0	0
Concensus	11	11			0	0	0	0							4		0			0	0	0	0	0	2			0	

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Customer
POC and Phone: ______________________________

Customer
Office Symbol: ______________________________

Date: ____________________

Division: OEMO

TECHNICAL REPORT SATISFACTION SURVEY
(AF PREMIER Program Job Requirements/Physical Demands Survey)

This survey is used to help us improve our service to you. Your answers will be held in confidence and will significantly impact how we allocate resources to meet your needs. Upon completion of your review, please mail or fax (DSN 240-2288/Comm 210-536-2288) this form to our Quality Assurance office (OEPQ). Thank you very much!

GRADING SCALE:	EXTREMELY DISSATISFIED	DISSATISFIED	SLIGHTLY DISSATISFIED	SLIGHTLY SATISFIED	SATISFIED	EXTREMELY SATISFIED	N/A
	1	2	3	4	5	6	

FORMAT: Is the report understandable and well organized?	1	2	3	4	5	6	N/A
CONTENT: Does it provide you with necessary program implementation guidelines or data collection tools?	1	2	3	4	5	6	N/A
USEFULNESS: Did you use this product and, if so, was it easy to use?	1	2	3	4	5	6	N/A
QUALITY: Are you satisfied with the quality of this product?	1	2	3	4	5	6	N/A
SUPPORT: Are you satisfied with the support we have provided on this product?	1	2	3	4	5	6	N/A
OVERALL: Overall, how would you rate this product?	1	2	3	4	5	6	N/A

Comments/Suggestions: Did you find any errors or omissions? Will you continue to use this product? Are there any specifics of this product you would like to discuss? Are there other services you would like provided in the future? (Use back of page if more space is required.)

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